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OF THE PUBLIC SERVICE

REGULATIONS

FOR

SECONDARY SCHOOLS.

(From 1st AUGUST 1903 to 31st JULY 1904.)

Presented to both Houses of Parliament by Command of His Majesty.

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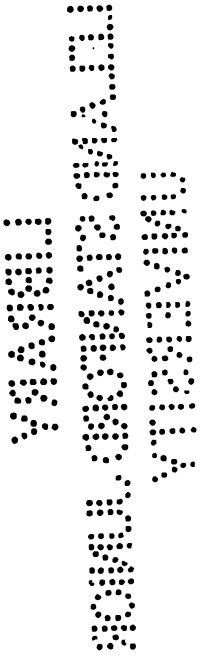

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MEMORANDUM.

These Regulations supersede those for the year 1902–1903.

A separate Volume is issued by the Board containing **Syllabuses,** and Lists of Apparatus.

The divisions in Science and Art Subjects other than Mathematics (Subject V.), formerly described as Elementary Stage and Advanced Stage, are now described as Stage 1 and Stage 2, and the divisions in Science Subjects, formerly known as Honours Part I. and Honours Part II., are now described as Stage 3, and Honours.

Copies of any of the forms referred to in these Regulations will be supplied on application, personally, or by letter addressed to The Secretary, Board of Education, South Kensington, London, S.W.

Official communications should be written upon foolscap paper and sent in envelopes addressed to The Secretary, Board of Education, South Kensington, London, S.W. The postage need not be prepaid, and it is particularly requested that Post Cards and Correspondence Cards may not be used.

Telegraphic Address: "Secondary Education, London."

BOARD OF EDUCATION.

Regulations for Secondary Schools.*

PART I.

GRANTS TO SECONDARY SCHOOLS.

Parliamentary grant.

1. The sum granted by Parliament for Secondary Schools will be administered by the Board of Education (hereinafter called the Board) under the following Regulations.

Conditions of grant.

2. A school or class must be efficient and necessary for the circumstances of the locality; must not compete unduly with a neighbouring school or class; and from its character and financial position must be eligible to receive aid from public funds. It must be open at all times to the inspection of the officers of the Board.

Religious instruction.

3.—(*a.*) A scholar attending under these Regulations as a day scholar at a Secondary School or Class shall not be required, as a condition of being admitted into or remaining in the school or class, to attend or abstain from attending any Sunday school, place of religious worship, religious observance, or instruction in religious subjects in the school, or class or elsewhere; and

(*b.*) The time for religious worship or for any lesson on a religious subject shall be conveniently arranged for the purpose of allowing the withdrawal of any such scholar therefrom.

* These Regulations do not apply to Schools conducted as Evening Schools under the Regulations of the Board.

Management.

4.—(*a.*) Every school or class must be under the superintendence of a body of Governors or Managers responsible to the Board, to whom the grant will, as a rule, be paid. It must not be conducted for private profit or farmed out to the Teacher. The Governors or Managers must appoint a person to act as correspondent with the Board.

(*b.*) The courses of instruction and the school fees must be suitable to the circumstances of the locality, and be approved by the Board.

(*c.*) The Board will not in general recognise schools or classes in which no fees are charged, but they will be prepared, in certain cases, to approve the remission of fees to individual students.

Holders of scholarships, exhibitions, and studentships, may be exempted from the payment of school fees.

Application of income.

(*d.*) A full account of the income and expenditure of all schools and classes must be furnished annually to the Board.

Schools or classes managed by a public company, in the Articles of Association of which provision is made that no dividend shall be paid exceeding 5 per cent. per annum, which received grants from the Board in the previous school year, will not, for the school year to which these regulations apply, be considered as conducted for private profit, provided they show that the capital is not nominal, but has absolutely been expended in buildings or maintenance.

Local Education Authorities.

5.—(*a.*) The Governors or Managers of any school or class for which grants are desired must apply each year for recognition to the Board, who, in considering the application, will consult the Local Education Authority and have regard to the co-ordination of all forms of education in the area of the Local Education Authority.

(*b.*) Where Part II. of the Education Act, 1902, is not in operation, the Council of any County or County Borough will be treated as the Local Education Authority for the purpose of these regulations.

Revision of grant.

6. If any of the conditions on which the grant is awarded are not fulfilled, or if the instruction or management is inefficient, the Board may withhold the grant, or, if they think fit, pay the grant with or without deductions, warning the Governors or Managers that a grant will not again be paid under similar circumstances. Grants may be refused on students whom the Inspector

6.—(*cont.*)
reports as unqualified from want of sufficient preliminary training, or other cause, to take advantage of the instruction.

Local support.

7.—(*a.*) Grants are intended to supplement and not to supersede local effort, and must be expended to the satisfaction of the Board.

(*b.*) The Board consider that at least 25 per cent. of the expenditure of a school or class should be met from sources other than the Board's grant, such as fees, subscriptions, grants from the local authority, or endowments.

Premises and equipment.

8.—(*a.*) The premises must be sanitary, convenient for teaching purposes, adapted to the circumstances of the school or class, and provided with satisfactory equipment and appliances.

(*b.*) In the case of schools recognised or desirous of being recognised under Division A or Division B (*see* below), new school sites or enlargements, and the plans of new school buildings and enlargements, must be approved by the Board.

Qualifications of Teachers.

9. The teaching Staff must be sufficient. The teachers must, as a rule, be paid by fixed salaries. They must be registered in column B of the Official Register of Teachers, or must possess such other qualifications as may be required by the Board. A teacher's employment at other times must not be such as will prevent the efficient discharge of his duties at the school or class.

Record of students and attendance registers.

10.—(*a.*) Governors or Managers must keep a record of the students who join the school or class. They are responsible for the accuracy of the registration of the attendance of all students in respect of whom grants are claimed.

Persons excluded from Registration.

(*b.*) No attendances may be counted for the purposes of grants in the case of any student who is on the register of attendance at any other school or class under Government inspection.

For the year ending 31st July 1904 this restriction will not apply in the case of any student registered under Sections 34 to 45 of these Regulations on account of whom a grant is payable under the Board's Regulations for the Instruction and Training of Pupil Teachers.

For detailed rules, *see* Appendix A.

School year.

11.—(*a.*) A school or class may apply for recognition at any time, but the school year will in general be held to begin on the 1st August and to terminate on the 31st July. The Board, however, in the case of a school recognised under Division A or Division B (*see* below), will be prepared to recognise a school year ending on the 31st December on the receipt of a special application from the Managers.

Inspection under Board of Education Act, 1899.

(*b.*) Any school applying for and receiving recognition under Division A or B will be held to have applied for inspection of the school as a whole under the Board of Education Act, 1899, and will be inspected accordingly at such periods as the Board shall determine.

DIVISION A.

12.—(*a.*) The school must provide a thorough and progressive course in Science, forming part of a course of general education.

(*b.*) Students whom the Inspector considers to be unfitted to benefit by the course, and students under 12 years of age, unless specially allowed by the Inspector, must be excluded.

General conditions.

13.—(*a.*) The instruction must be methodically carried on according to one or other of the courses laid down, or according to a course framed on similar lines which has been specially submitted to and approved by the Board. A school will not be recognised unless it has at least 20 qualified students. After a school has been working for two years under the provisions of this Division recognition will be withheld unless it has a fair proportion of students taking the Advanced course.

(*b.*) In determining the proportion, the Board may take into consideration cases in which the Inspector is satisfied that students, having passed through the elementary course of the school, are actually pursuing a course which includes adequate instruction in Science in a similar school elsewhere, or in a Pupil Teacher Centre approved by the Board, or in technical or other similar Institutions.

Laboratories and time

14.—(*a.*) The school must possess sufficient and properly equipped laboratories, which must be available for preparation work by students of the school, beyond the school hours of the time-table.

14.—(*cont.*)

(*b.*) The time-table must be submitted in duplicate on Form 122 to the Inspector not later than the first week of each school year, and a copy must be conspicuously exhibited in the school. No modification of the time-table may be made without due notice.

15. The attendance of the students must be recorded on the special attendance register (Form 486*d*). Separate registers should be kept for each form, and in no case may the attendances in different years' courses be entered on the same register. Not more than two attendances may be registered for any one student on any one day. Registrati

16.—(*a.*) Not less than 13 hours per week must be allotted to instruction in the obligatory subjects, of which not more than five hours may be allotted to Mathematics. Not less than 10 hours must be allotted to the other approved subjects, which must include English subjects and at least one foreign language. Two of these 10 hours may be allotted to some form of Manual Instruction, and two others of them to Mathematics or Drawing. Instructi

(*b.*) Each lesson in Practical Work in a subject of Science must be of at least one hour and a half's duration.

Elementary Course.

17.—(*a.*) The Elementary Course may extend over two years, to afford sufficient time for thorough and progressive instruction. Element course.

(*b.*) Reasonable latitude will be allowed to the teacher in the preparation of a scheme of instruction, provided it is sound, satisfactory in amount, and makes provision for proper practical work.

General Elementary Course.

Obligatory Subjects.

1. Mathematics (as in Stage 1 of Subject V., or Stage 1 or 2 of Subject V. p.).
2. Physics including the fundamental principles of Mechanics, (theoretical and practical).

17.—(*cont.*)

3. Chemistry (theoretical and practical).
4. Drawing. (Suggestions will be found in the Circular on Primary Drawing issued by the Board.)
5. Practical Geometry.

Alternative Course for Girls.

18. In the case of girls, instruction in a Biological Subject may, with the approval of the Board, be substituted for Physics; and either Elementary Science (including the fundamental principles of Chemistry and Physics) or Elementary Hygiene may be substituted for Chemistry. Practical work will be required in each case.

Advanced Courses.

Advanced Course.

19.—(*a.*) On the completion of the Elementary Course the work of the students should be continued in one of the following Advanced Courses. Students should not be admitted to these courses unless they are fully qualified to take advantage of the advanced instruction. When a school wishes to develop instruction in Drawing, it should submit a special Advanced Course, and may at the same time suggest a slight modification of the prescribed Elementary Course with a view to rendering it a suitable introduction to the advanced teaching.

(*b.*) When a student has received two years' instruction under the Board in Practical Geometry, it ceases to be an obligatory subject so far as that student is concerned, and, in its place, one of the optional subjects may be submitted for approval.

20.

A.—Physical Course.

Obligatory Subjects.

Advanced Course, Physical.

1. Mathematics, Subject V., Stage 2, 3, or 4, or Subject V. p., Stage 2, or 3.
2. Geometry, Subject I., Stage 2.

Stage 1 may be taken, provided that a fair proportion of the students are instructed in Stage 2.

20.—(*cont.*)

3. A general course in Advanced Physics approved by the Board, or

Sound, Subject VIII*a.*, or Light, Subject VIII*b.*, or Heat, Subject VIII*c.*, or Magnetism and Electricity, Subject IX.	Stage 2, with Practical Instruction.

4. Inorganic Chemistry, Subject X. (Theoretical and Practical), Stage 2.

Optional Subjects.

5. Theoretical Mechanics, Subject VI., Divisions *a* or *b*.

6. Physiography, Subject XXIII.

7. Organic Chemistry, Subject XI. (Theoretical and Practical.)

8. Drawing of a more advanced character than that taken in the Elementary Course.

B.—Mechanical Course.

Obligatory Subjects.

1. Mathematics, Subject V., Stage 2, 3, or 4, or Subject V. p., Stage 2, or 3. Advanced Course, Mechanical.

2. Geometry, Subject I., Stage 2.

Stage 1 may be taken, provided that a fair proportion of the students are instructed in Stage 2.

3. A general course in Advanced Physics approved by the Board, or

Heat, Subject VIII*c.*, or Magnetism and Electricity, Subject IX.	Stage 2, with Practical Instruction.

4. A general course in Theoretical and Applied Mechanics with practical work, or

Theoretical Mechanics, Subject VI., Divisions *a* and *b*, together with Applied Mechanics, Subject VII., or Steam, Subject XXII.

Practical work must be taken in at least one of the divisions of Mechanics.

20.—(*cont.*)

Optional Subjects.

5. Inorganic Chemistry, Subject X., Theoretical and Practical, Stage 2.

6. Machine Construction and Drawing, Subject II., or Building Construction, Subject III.

7. Drawing of a more advanced character than that taken in the Elementary Course.

C.—Biological Course.

Obligatory Subjects.

Advanced Course, Biological.

1. Geometry, Subject I., Stage 2.

Stage 1 may be taken, provided that a fair proportion of the students are instructed in Stage 2.

2. Physiology, Subject XIV., with practical instruction, or General Biology, Subject XV., with practical instruction.

3. Botany, Subject XVII., with practical instruction.

4. Inorganic Chemistry, Subject X., Theoretical and Practical, Stage 2.

Optional Subjects.

5. A course in Electricity, of the nature which will be of use in Physiolcgical Study, with practical instruction.

6. Mathematics, Subject V., Stage 2, 3, or 4, or Subject V. p., Stage 2, or 3.

7. A general course in Advanced Physics approved by the Board, or

Sound, Subject VIII*a*., or Light, Subject VIII*b*., or Heat, Subject VIII*c*.	Stage 2, with Practical Instruction.

8. Hygiene, Subject XXV.

9. Drawing of a more advanced character than that taken in the Elementary Course.

20.—(*cont.*)

D.—Alternative Course for Girls.

Obligatory Subjects.

1. Mathematics, Subject V., Stage 2, 3, or 4, or Subject V. p., Stage 2 or 3.
2. Geometry, Subject I., Stage 1 or 2. (This subject becomes an optional subject where Practical Geometry has been taken in the Elementary Course.)

Advanced Alternative Course for Girls.

3. Hygiene, Subject XXV.
4. Physiology, Subject XIV., or Botany, Subject XVII.
5. Physiography, Subject XXIII.

With Practical Instruction in any two of these subjects.

Optional Subject.

6. Drawing of a more advanced character than that taken in the Elementary Course.

Any Advanced Course submitted as an alternative to the above must include Hygiene.

Special Courses for Schools in Rural Districts.

21. The following courses may be adopted by Schools in Rural Districts:—

Courses in Rural Districts.

Elementary Course.

Obligatory Subjects.

1. Mathematics.
2. Elementary Science, including the fundamental principles of Chemistry and Physics (with practical work).
3. Biology or Botany (practical work may be in the farm, field or garden).

Elementary Course.

21.—(*cont.*)

4. Drawing, Modelling, Practical Geometry, or Practical Mathematics.

Manual Instruction in its application to workshop and garden must also form part of the course.

Advanced Course.

Advanced Course.

Not less than four of the following subjects should be selected to form the course. Subject to the approval of the Board, any combination of subjects may be chosen which may be suited to the school or the locality :—

1. Agricultural Science and Rural Economy, Subject XXIV. (with practical work).
2. Chemistry applied to Agriculture (with practical work).
3. Botany (with practical work).
4. Biology (with practical work).
5. Physiology (human and animal).
6. Geology (with field work).
7. Zoology.
8. Mechanics (as applied to agricultural processes).
9. Practical Mathematics.
10. Land Surveying.

Practical work in at least two of the subjects 1 to 8 must be taken.

Alternative Courses for Girls.

Alternative Courses for Girls.

Elementary Course.

Obligatory Subjects.

Elementary Course.

1. Elementary Mathematics.
2. Physiography.
3. Biology.
4. Botany or Hygiene (obligatory in the second year only).
5. Drawing, Modelling, or Elementary Practical Geometry.

Practical work in at least one of the Subjects 2, 3, 4, must be taken.

21.—(*cont.*)

This course is intended to cover two years.

Physics or Chemistry may be substituted for Physiography in the second year.

Two hours at least must be given to Manual subjects, such as Needlework, Cookery, Dairy work, or Laundry work.

Advanced Course.

Stage 2 of at least one subject must be taken. Advanced Course.

Obligatory Subjects.

1. Mathematics.
2. Botany or Biology.
3. Hygiene or Physiology.
4. Physiography or Physics or Chemistry.
5. Agricultural Science and Rural Economy (Poultry-keeping, Dairying, Bee-keeping, etc.).

Practical work in at least two of the Subjects 2, 3, 4, must be taken.

Optional Subjects.

One of any of the above subjects not taken, or either Geology or Zoology, or an approved Art Subject.

22.—(*a.*) In the courses laid down in the preceding Section a minimum of eleven hours weekly, exclusive of the time given to Manual Instruction, must be given to the obligatory subjects. Time to be devoted to obligatory subjects.

(*b.*) When, however, less than thirteen hours is so given, the total grant will be proportionately diminished; thus for twelve hours the grant would be diminished to $\frac{12}{13}$ths of the total amount.

Manual Instruction.

23. Manual instruction should form part of the Elementary Course of each student, unless special exemption is given by the Board. Manual instruction.

(*a.*) For Boys—The Manual Instruction—

(i.) must be in the use of the ordinary tools used in handicrafts in wood or iron, and must be given in a properly fitted workshop for at least one hour and a half a week;

(ii.) must be connected with instruction in drawing, that is to say, the work must be from drawings to scale previously made by the scholars;

23.—(*cont.*)

(iii.) may be given by one of the regular teachers of the school or centre at which the Manual Instruction is given if he is sufficiently qualified; if not, he must be assisted by a skilled artisan, and care must be taken to make such arrangements as will ensure the maintenance of good order and discipline.

(*b.*) For Girls—The Manual Instruction may take the form of Cookery, Laundry work, Dairy work, or Needlework.

Any one or two of these subjects may be taken.

GRANTS.

Grants.

24.—(*a.*) After a school has been working for five consecutive years as a recognised School of Science, or School of this Division, or partly as one and partly as the other, it will receive, if the Board so determine, an annual grant on each student in the Elementary and Advanced Courses respectively who has made not less than 250 attendances, provided that the Inspector reports that continuous instruction has been given in the approved course throughout the school year.

(*b.*) This grant will be equivalent to the average amount* paid on such students in each Course in the preceding year. The annual grant thus calculated will be subject to reassessment as the result of a detailed inspection, which will be held, as a rule, at intervals not exceeding three years.

25. On any reassessment taking place after July 31st, 1904, the provisions as to the rate of grants contained in § 27 will apply to all students in the Elementary Course, and after July 31st, 1906, to all students.

26.—(*a.*) A school complying with the provisions of this Division which was recognised as a School of Science under the Regulations of the Board before the 31st July 1902, but which has not been working as such for five consecutive years, will continue to have the grant assessed on the scale and subject to the conditions laid down in the Directory of 1901, unless it applies to have the grant assessed under the provisions of the following section.

* Where, owing to the operation of Circular 565, a reduced grant has been made in the preceding year, the reduction will be disregarded in determining the average amount.

26.—(*cont.*)

(*b.*) After July 31st, 1904, the grant for students in the Elementary Course will not exceed the limit laid down in the following section.

27.—(*a.*) The grant payable in respect of a school recognised under the provisions of this Division after the 31st July 1902 will be calculated at the following rates :—

On each student who has made not less than 250 attendances, provided that the Inspector reports that continuous instruction has been given in the approved course throughout the school year :—

in the Elementary Course from 70*s.* to 120*s.*
in the Advanced Course from 80*s.* to 180*s.*

(*b.*) A student, if moved during the school year from the Elementary to the Advanced Course, will be regarded for the purposes of the grant as an Elementary Course Student.

(*c.*) These grants will be assessed annually on the reports of the Inspectors.

28. Students taking the Elementary Course are not allowed to sit at the May or June Science and Art Examinations. Students taking the Advanced Course may not sit for Stage 1, Science and Art Examinations, except for the purpose of competitions for Exhibitions and Scholarships, in which case special permission must be obtained and the fees for examination must be paid. Examinations.

29. Grants are not payable for more than four years in all on account of any one student. No grant will, as a rule, be payable on any student who enters later than one month after the beginning of the course, or leaves before the last month thereof. In cases where the proportion of students in the Advanced Course falls below 20 per cent. of the whole, any grant allowed on account of Elementary Course Students in excess of four times the number of Advanced Course Students will be at such reduced rate, not exceeding 40*s.* per student, as the Board, after consideration of the Inspector's Report, may determine. Limitation of grants.

30. A student who attends a three or four years' course will be granted a certificate provided that he Certificates.

30.—(*cont.*)

has obtained a success in Stage 2 or 3, or in Honours, of three of the obligatory subjects of his Advanced Course. This certificate will be issued on application being made by the Governors or Managers on Form 637. No other class of certificate will be issued to these schools.

For the award of this Certificate Theoretical and Practical Inorganic Chemistry count as one subject only, as do the various stages of Mathematics.

DIVISION B.

eneral onditions.

31.—(*a.*) A school may submit a course of general instruction including a scheme for a three or four years' course in Science for forms in which the average age of the students is above 12, and which are reported by the Inspector as able to benefit by such instruction, provided that the number of qualified students is not less than 20.

(*b.*) The time-table of the curriculum of the whole school must be submitted in duplicate on Form 124 to the Inspector, not later than the first week of each school year, showing that, in the forms in respect of which grants will be claimed, provision is made that not less than nine hours per week, or one-third of the total number of hours of instruction per week, whichever shall be least, will be devoted to instruction in Science and in Mathematics, as in Subject V., Stages 1, 2, 3. Where the proper treatment of the subject requires it the instruction in Science must be both theoretical and practical, the latter being conducted with such laboratory equipment as the Inspector may report to be necessary.

(*c.*) Where the total number of hours per week exceeds 22 hours, not less than 4 hours, and in other cases not less than one-half the required minimum for Science and Mathematics together, shall be given to Science.

(*d.*) The yearly courses must be taken in the prescribed sequence, provided that a student may, with the sanction of the Inspector, be placed in the course

31.—(*cont.*)

for any year for which his previous instruction has qualified him.

32.—(*a.*) Grants will be paid to these schools for each student who has made not less than 240 duly registered attendances during the school year at the following rates, provided that the Inspector reports that continuous instruction in the approved courses has been given during that period throughout the school year. Grants.

For the purpose of registration not more than two attendances per day may be registered on behalf of a student, and, as a rule, no meeting of less than two hours' duration will be recognised.

The rate of grants will be as follows :—

For the first 100 students:

For each student in attendance in the 1st or 2nd year's course a grant not exceeding eighteen pence for each complete week during which instruction in accordance with the approved time-table has been given.

For each student in attendance in the 3rd or 4th year's course a grant not exceeding twenty-six pence for each complete week during which instruction in accordance with the approved time-table has been given.

For students in excess of 100:

For each student in attendance in the 1st or 2nd year's course a grant not exceeding fifteen pence for each complete week during which instruction in accordance with the approved time-table has been given.

For each student in attendance in the 3rd or 4th year's course a grant not exceeding twenty-two pence for each complete week during which instruction in accordance with the approved time-table has been given.

(*b.*) These grants will be assessed annually, and in assessing them the Board will take into consideration (1) the Inspector's report on the efficiency of the school, particularly as regards its Science work, and (2) the

32.—(*cont.*)

average number of hours of instruction per week in all subjects of instruction given to forms recognised under this division.

(*c.*) In calculating the payments to schools claiming for students in excess of 100, the numbers in the first 100 on whom the higher and lower grants respectively will be paid, will be determined by the proportion that the total number of 1st and 2nd year's students bears to the total number of 3rd and 4th year's students.

Thus in a school of 160 students on whom a grant may be claimed and of whom 40 are in the 3rd or 4th years, the first 100 payments will be made on 75 1st and 2nd year's students, and 25 3rd and 4th year's students.

(*d.*) From the beginning of the school year 1904–5,20 per cent. of the students on whom grants may be claimed must as a rule be 3rd or 4th year's students, and grants for 1st and 2nd year's students combined may not be claimed on more than four times the number of 3rd and 4th year's students combined.

(*e.*) A student, if moved during the school year from one year's course to another, will be regarded for the purposes of the grant as a student in the year's course from which he was moved.

Restrictions.

33. A school recognised under either Division A or Division B will not, in respect of the students in either Division, be eligible for grants for any subject in Day Classes under the Board, except that students in Division B may be registered for attendance in a Day Art Class under these regulations.

SCIENCE AND ART DAY CLASSES IN SECONDARY SCHOOLS.

General conditions and future restrictions.

34. Grants will be paid to Day Classes in Secondary Schools for instruction in Science and in Art in accordance with the provisions contained in §§ 1 to 11 and 34 to 45 of these Regulations; but after July 31st 1904 no such grant will be paid to any School which is eligible for recognition under Division A or Division B.

Eligibility of students.

35. No student may be registered who is under 12 years of age.

Application for recognition.

36. The school or class must send to the Board Form 133 at least a fortnight before the date fixed for the commencement of the instruction. Unless this is done the grant will be subject to a deduction. Applications will not, as a rule, be received after the 1st October.

Course of instruction and syllabus.

37. Arrangements should be made, so far as practicable, to provide for a progressive course or courses of instruction for students attending in successive school years. Syllabuses of subjects in which the Board hold examinations are issued in a separate volume. Governors or Managers of schools or classes who wish to adopt any other syllabus must submit it to the Board for their approval.

Time-table.

38.—(*a.*) The Time-table, which must be submitted in duplicate on Form 133*a* to the Inspector, must show the several subjects in which instruction is given, and the time allotted to each subject. At least a week's previous notice of any alteration in the Time-table affecting the days or hours of meeting or of a holiday or temporary closure of the school or class must be given to the Inspector. The Governors or Managers must also give a clear fortnight's notice to the Inspector of the date at which the school or class will close for the school year.

(*b.*) A deduction from the grant not exceeding 1*l.* may be made if the Inspector finds the school or class closed at a time when the Time-table provides for instruction being given.

Time to be given to each subject.

39. No grant will be made for instruction in any subject in which less than 20 hours of instruction is given.

40.—(*a.*) No student's attendance in any subject may be counted unless he has received at least 14 hours of instruction in that subject.

(*b.*) Where students of a school or class become eligible for registration too late to receive 14 hours' instruction in any subject before the end of the school year, the Board may allow the attendances of such students to

40.—(*cont.*)

be carried forward to the following school year, provided that no grant will be made in respect of a student who receives in all less than 14 hours' instruction in that subject.

41. Not more than 320 hours of instruction may be counted for any student in one year.

Payments.

42.—(*a.*) Payments are made on the attendance of students at instruction and in certain cases on the results of examination. For rules governing the rate of the payments, *see* §§ 44 and 45.

Certificates required from the Managers.

(*b.*) The payments are made when the prescribed conditions have been complied with. The Governors or Managers must certify that these conditions have been fulfilled.

Assessment of efficiency of class.

43. The rates payable under § 44 will be determined by the Board upon (*a*) the Inspector's Report; (*b*) the past record of the school or class, and, in certain cases, (*c*) the success of the students at the examinations of the Board.

Subjects and grants.

44. A grant may be paid for each complete 20 hours of instruction received by registered students in any of the following subjects at one of the rates applicable to the Division in which the subject is included.

(*a.*) Art.

The ordinary rate of grants will be from 1*s.* 6*d.* to 2*s.* 6*d.*

This rate may, however, be increased up to 7*s.* 6*d.*, according to the efficiency of the instruction and equipment, and the qualifications of the teachers.

The hours of a student's instruction between 120 and 320 will be paid upon at the ordinary rate.

No lesson of less than one hour will be allowed to count as instruction in Art.

44.—(*cont.*)

(*b.*) SCIENCE.

Any generalised or special branch of Science, including Mathematics, will be accepted, if a suitable syllabus is submitted.

(For List of Subjects in which the Board hold examinations, *see* § 48.)

The ordinary rate of grants payable will be from 1*s.* 6*d.* to 2*s.* 6*d.*

This rate may be increased for Elementary work up to 4*s.* 6*d.*, and for Advanced work up to 10*s.* according to the efficiency of the instruction and equipment, the experimental illustration of the teaching, and the qualifications of the teacher.

For systematic practical instruction given under the same conditions, and in lessons of not less than one hour and a half in an approved laboratory, grants up to 6*s.* 6*d.* and 12*s.* 6*d.* respectively may be awarded.

The hours of a student's instruction between 240 and 320 will be paid upon at the ordinary rate.

No lesson of less than 40 minutes will be allowed to count as instruction in the theory, or of less than 1½ hours in the practical work of the above subjects.

Scale of Payments on Results.

45. The following grant may be made on the Results of the Examination of students who have received during the School year at least twenty registered lessons in each subject in respect of which the grant is claimed, each lesson to be of an hour's duration in the case of an Art subject or of a theoretical subject of Science, and of an hour and a half's duration in a practical subject of Science.

(*a.*) 3*l.*, 2*l.*, and 1*l.* for an excellent, first class, or second class respectively in Drawing and Modelling from the Life and Architectural Design.

(*b.*) 6*l.* and 3*l.* for a first or second class respectively in Honours.

45.—(*cont.*)

(*c.*) If the student, on account of whom the grant under (*a*) and (*b*) is claimed, has been previously successful in the same subject, or in a corresponding subject, the grant on his account will be reduced by the grant which would be payable on such previous success; but when such previous success has been obtained in a school or class under the same Governors or Managers, and no grant has been made for it, the Board may allow the full claim. Grants for not more than three successes, whether in Honours or in Drawing from Life or Modelling from Life or Architectural Design, will be allowed for the same student in the same year.

INSPECTION.

Visits of Inspectors.

46.—(*a.*) The Inspectors of the Board will from time to time visit the schools and classes and report on, among other things, the sufficiency, condition, and suitability, of the premises and fittings; the sufficiency of the apparatus and equipment; the whole curriculum; the character and quality of the instruction in all subjects; the sufficiency of the teaching staff for the number of students under instruction; the progress of the students, which they may test in such manner as may be necessary; the constitution and working of the managing body; and the manner in which the Board's regulations are carried out.

(*b.*) A meeting of the Governors or Managers, for which sufficient notice will be given, must, if required, be held when the school or class is inspected.

(*c.*) The Inspectors may require the production of the Accounts and of any other necessary papers to enable them to verify the income and expenditure in respect of the school or class.

In Day Classes these provisions will apply *mutatis mutandis*.

Inspection of Secondary Schools under Section 3 of the Board of Education Act, 1899.

Application for inspection.

47. The Board will be prepared to conduct an inspection under Section 3 of the Board of Education

47.—(*cont.*)

Act, 1899, upon receiving an application for such inspection from the Governing Body of the school.

The Board cannot undertake to arrange for an inspection to take place in less than two months from the date on which the formal application for inspection is received.

Extent of Inspection.

The inspection will cover (*a*) the administration of the school, (*b*) the condition of the school buildings, and (*c*) the education given throughout the school.

(*a*) For the purposes of the Administrative Inspection there will be a conference between the Inspectors and the Governing Body.

(*b*) The Inspection of the school buildings will include sanitary inspection, for which purpose a sanitary expert may, in special cases, be called in. It will also include an inspection of the provision for recreation and of all boarding houses conducted by the Governors or under their license or by any member of the school staff.

(*c*) The Educational Inspection will deal with all the subjects comprised in the curriculum of the school, but not by way of systematic examination either written or oral.

Charge for Inspection.

The charge for inspection, based on the ordinary curriculum, will be as follows, viz.:—

	£	*s.*	*d.*
For a School having not more than 50 students - - - -	5	0	0
For a School having more than 50 students and not more than 75 - - -	7	10	0
For a School having more than 75 students and not more than 100 - -	10	0	0
And so on.			

In assessing the charge for any school not containing a school conducted under Division A every two students above the number of 400 will be counted as one; and for any school containing a school conducted under Division A, every two students in the school under that Division will be counted as one, and should the resulting number in the whole school exceed 400, every two units over 400 will be counted as one.

47.—(*cont.*)

A minimum charge of 5*l.* will in all cases be made. When a sanitary expert is employed there will be an additional charge for his services.

Report on inspection.

The Report of the Board on the efficiency of the school at the time of inspection will be sent to the Governing Body, and to the Headmaster or the Headmistress of the school, and also to the County Council, if that body contributes to the cost of the inspection under section 3, sub-section 2, of the Act. The report, if published, must be published in its entirety.

Where the school is in receipt of grants from the Board, the inspection will be combined with that required for the assessment of the grant.

PART II.

EXAMINATIONS IN SCIENCE AND ART.

48. **Examinations** are held by the Board, under the conditions stated in this Part of these Regulations, in the following subjects :—* Subjects of examination.

(*a.*) Science, including Mathematics.

I. Practical Plane and Solid Geometry.
II. Machine Construction and Drawing.
III. Building Construction.
IV. Naval Architecture.
VII. Applied Mechanics.
XXII. Steam.
V*p*. Practical Mathematics.

V. Mathematics.
VI*a*. Theoretical Mechanics (Solids).
VI*b*. Theoretical Mechanics (Fluids).
XX. Navigation.
XXI. Spherical and Nautical Astronomy.

VIII. Sound, Light, and Heat.
VIII*a*. Sound.
VIII*b*. Light.
VIII*c*. Heat.
IX. Magnetism and Electricity.
XXIII. Physiography (Sec. 1, Stage 1).

X. Inorganic Chemistry.
X*p*. Inorganic Chemistry (Practical).
XI. Organic Chemistry.
XI*p*. Organic Chemistry (Practical).
XIX. Metallurgy.
XIX*p*. Metallurgy (Practical).

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* The "Stages" or other sub-divisions of the subjects in which the examinations are held are those mentioned in the syllabuses on which the papers set at the examinations are based. These syllabuses are published in a separate volume.

N.B.—The divisions in Science and Art subjects other than Mathematics (Subject V.), formerly described as Elementary Stage and Advanced Stage, are now described as Stage 1 and Stage 2 respectively, and the divisions in Science subjects formerly known as Honours Part I., and Honours Part II., are now described as Stage 3 and Honours respectively.

48.—(*cont.*)

XII. Geology.
XIII. Mineralogy.
XVIII. Principles of Mining.
XXIII. Physiography.

XIV. Human Physiology.
XV. General Biology.
XVI. Zoology.
XVII. Botany.
XXV. Hygiene.

XXIV. Agricultural Science and Rural Economy.

(*b.*) Art.

Freehand Drawing in Outline.
Model Drawing.
Drawing in Light and Shade from a Cast.
Drawing on the Blackboard.*
Geometrical Drawing (Art).
Perspective.
Memory Drawing of Plant Form.
Drawing of Common Objects from Memory.
Anatomy.
Drawing from the Antique.
Drawing the Antique from Memory.
Drawing from Life.
Painting from Still Life.
Painting Ornament.
Historic Ornament.
Principles of Ornament.
Design.
Architecture.
Architectural Design.
Modelling from the Antique.
Modelling the Head from Life.
Modelling from Life.
Modelling Design.

* For the special conditions affecting the Examination in Drawing on the Blackboard, *see* Section 50 (*d*).

49. These examinations are intended for—

(i.) registered students in any subject of Science, for their examination in that subject; Local Examinations.

(ii.) registered students in Art, for their examination in Art;

(iii.) registered students in an organised course in an Evening school recognised by the Board, for their examination in any subject of such course;

(iv.) teachers;

in schools recognised as eligible to earn grants from the Board.

For the conditions on which the examinations may be attended by other (External) candidates, *see* Section 58.

The examinations in 1904 will be held on the dates specified in the Examination Time-tables given in Appendix B. (Evening Examinations) and Appendix C. (Day Examinations).

No candidate may be examined in the same subject at the evening examinations and at the day examinations in the same year.

50.—(*a.*) Examinations in Practical Chemistry (Subjects X*p.* and XI*p.*), and in Practical Metallurgy (Subject XIX*p.*), are held only in laboratories equipped in accordance with the requirements appended to the Board's Syllabuses for these subjects. Practical examinations in Science.

Where the number of candidates for examination working at the same time exceeds the number for which the laboratory is approved, the candidates may be examined in divisions. Not more than two such divisions will be allowed, and the number of candidates in each division working at the same time must not exceed the number for which the laboratory is approved.

(*b.*) Practical examinations for candidates in Honours in certain subjects may be held at South Kensington, or at some other centre, in addition to a written examination (*see* syllabus of each subject). Such practical examinations will be held as early as possible in June or July.

Candidates who are instructed to attend these examinations at South Kensington or any other centre, receive a maintenance allowance of 5*s.* 6*d.* a night, while required to be absent from home, and third class railway fare; but no cab or omnibus fares are allowed.

50.—(*cont.*)

(*c.*) Special examinations may be held for Navigation Schools. Particulars of these examinations and of the capitation grants payable to such Schools (Form 491*a*) will be forwarded on application.

(*d.*) Examinations in drawing on the blackboard will be held by Inspectors during the months of April, May, and June 1904 at approved centres.

Managers who desire the approval of any particular centre must apply to the Board not later than 30th November 1903, stating the probable number of candidates. No examination will be held at any centre unless at least 30 candidates have applied for examination.

A list of approved centres, showing in each case the name and address of the Secretary, will be issued to the Managers of Schools of Art and Art Classes during the month of January.

Managers must forward Form 278 to the Board, through the Secretary of an approved centre, on or before 1st March 1904.

Grades of success.

51. The grades of success at the Examinations are "first class" and "second class."

Exceptions.—(1) In Section 1 of Stage 1 of Science Subjects XV. and XXIII. there is only one grade of success, viz.: "pass."

(2) In the Art subjects of drawing and Modelling from the Life and Architectural Design there is a further grade of success, viz.: "excellent."

Conduct of Examinations.

52. For the conduct of examinations the Board recognize

either (1) Special Local Secretaries and Assistants;

or (2) Special Paid Superintendents;

or (3) Managers.

Special Local Secretary and Assistants.

53. Where numerous examinations have to be held, or where large schools or classes have to be examined, the Board may require the appointment of a Special Local Secretary to manage the whole business of the examinations. This officer may receive payment as hereinafter provided.

Nomination and appointment of Special Local Secre-

The Special Local Secretary may be appointed by the Board on the nomination of a County or County Borough Council.

53.—(*cont.*)

Assistants will be appointed by the Board to act as Superintendents at the examinations on the nomination of the Special Local Secretary. Assistants for Special Local Secretary.

The nomination of the Special Local Secretary must be sent to the Board not later than **15th February 1904.**

Candidates for the examinations, their relatives, their teachers, or other persons who have a direct interest in the success of candidates for examination are ineligible to act as Special Local Secretaries or Assistants for the district in which such candidates are to be examined.

When a Special Local Secretary has been appointed, the Board will, as a rule, correspond with him alone on all subjects connected with the examinations. He must arrange for holding the examinations at convenient centres, subject to the approval of the Board, the number of these centres being as few as possible. As he is charged with the general supervision of the examinations, he may not act in the place of an assistant except either in the case of an emergency, or on an occasion on which there is an examination at but one centre.

The Special Local Secretary, after noting the application made to him on the Forms 119, must forward the forms, together with the fees of the candidates, to the Board not later than the 27th March for the evening examinations, and 5th May for the day examinations. The Special Local Secretary should refuse to provide accommodation for any candidate whose name has not been returned to him before he transmits the formal application for papers, etc., to the Board.

54. The Special Local Secretary may receive payment for the services of himself and his Assistants on the under-mentioned scale out of a fund to which, on the prescribed certificate (Form 983) being furnished, the Board will make a contribution equivalent to one-half the whole expense of the examination on the scale laid down; provided that the contribution so made does not exceed two shillings and sixpence for each paper or exercise worked at the examination, exclusive of papers or exercises in Stage 1. Local contribution toward the expenses of examination.

The financial arrangements of the examinations are, subject to the regulations of the Board, entirely under the control of the body by which the Special Local Secretary is nominated, to which body he is required to submit his accounts. The Special Local Secretary shall account for the fees paid by external candidates for examination to the nominating body, who will use them in helping to provide the moiety required from the locality for examination expenses to meet the grant given by the Board. Each school having students for examination may be required by the Special Local Secretary to pay its contribution prior to the time of the examination; the students of any school from which such contribution has been so required, but has not been received, may be excluded from the

54.—(*cont.*)

examination. In levying this contribution the balance of fees available should be taken as part of the local moiety.

The Special Local Secretary is allowed a fee* of half a guinea for each period of three or four hours during which an examination is to be held. When, however, he acts in place of an assistant he will receive no additional fee. He is also allowed a fee* of half a guinea for every 75 papers worked at the examination.

For attendance throughout an examination which extends over a period of three or four hours, each assistant who is required to attend for that period is allowed a fee* of half a guinea. Where that period is materially exceeded, the Board may allow a double fee.*

Superintendents.

55. Where a County or County Borough Council accepts responsibility for holding examinations for which no Special Local Secretary is appointed, it may nominate Special Paid Superintendents to conduct them. Other Managers may nominate Superintendents of examinations in Still Life Painting or Casting. Such Superintendents will be paid at the rates allowed to Special Local Secretaries' Assistants, and will be subject to the regulations, as far as they apply, for such assistants.

The nomination of Superintendents under this section must be sent to the Board not later than 15th March.

Examination Secretary.

56. Where no Special Local Secretary or Special Paid Superintendent is appointed, the conduct of the examination devolves upon the Managers of the school or class requiring examination, and the Board will recognise their Correspondent as Examination Secretary.

Where two or more schools or classes, within reasonable distance of one another, require simultaneous examination, the Board may call upon their Managers to appoint one of themselves as the Examination Secretary. He must make arrangements for the examination or examinations in question at a common centre.

No payment for the conduct of an examination is made by the Board to Managers or to an Examination Secretary under this Section.

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* These fees will not be paid by the Board in respect of Examinations in Stage 1. When an examination in Stage 1 is held concurrently with an examination in Stage 2, the same Superintendents may supervise both examinations provided the total number of candidates to which their supervision is restricted by the Regulations is not exceeded. The cost of additional Superintendents necessitated by the presence of Stage 1 Candidates must be defrayed wholly from local sources.

Application for Examination by Managers.

57. Managers must apply to the Board or, where such officer is appointed, to the Special Local Secretary, or to the Examination Secretary as the case may be, for examination papers on Form 119, not later than the 20th March* for the Evening examinations and the 30th April* for the Day examinations.

The Board cannot undertake to entertain late or irregular applications.

Where papers in Stage 1 of any subject are applied for, the form of application must be accompanied in each case by the sum of 1*s.* 6*d.* for each such paper asked for therein. For papers in Stage 1 of Practical Chemistry or Practical Metallurgy the fee will be 2*s.* 6*d.* per paper. The number of papers requisitioned cannot be subsequently varied, and no part of the remittance is returnable.

Examination of External Students.

58. External Candidates (*see* Section 49) must make an application, accompanied by the prescribed fee, to the Special Local Secretary (where one has been appointed) or to the Correspondent of the body conducting the examinations, by the 18th March* for admission to the Evening examinations, and by the 28th April* for admission to the Day examinations.

Special Local Secretaries, or Managers who hold an examination, must admit to it External Candidates who have made due application to them to sit.

Exceptions.—(1.) At the Day Examinations External Candidates can only be examined at centres where Examinations in the required subjects are to be held for other Candidates.

(2.) The admission of an External Candidate to an examination in Practical Inorganic Chemistry, Practical Organic Chemistry, Practical Metallurgy, or Modelling and Casting is not obligatory.

An External Candidate may be charged a fee of 2*s.* 6*d.* for each morning, afternoon, or evening of examination for which his name is registered. Where such a candidate is admitted to a subject named in Exception 2 above, the fee may be 3*s.* 6*d.* The fee of 2*s.* 6*d.* or 3*s.* 6*d.* is in addition to any examination fee payable to the Board under Section 57.

Custody of Examination questions.

59. The examination papers will be forwarded to the Special Local Secretary, or to the Examination

* For admission to the examination in Blackboard drawing, application should be made to the Secretary of the Centre. As to the date before which application should be made, *see* Section 50 (*d*).

59.—(*cont.*)

Secretary, as the case may be, who will be responsible for their safe custody and distribution.

Where any special circumstances render it desirable another person may be appointed to receive, take charge of, and distribute, the papers.

The packets of examination questions must not under any circumstances be permitted to pass into the hands of a teacher, of a candidate for examination, or of any other person interested in the success of the examination.

Regulations for Examination.

60. The detailed regulations (Form 91) for the conduct of the examinations are issued in due course to Managers and Special Local Secretaries who have applied for examinations in accordance with the rules.

Irregularities at Examination.

61. The Board may disallow examinations where there has been a breach of the Regulations, or where there is evidence of fraud. They will investigate cases of suspected irregularity, and may require any or all of the candidates to be re-examined. If any candidate should fail to appear at such investigation, or decline to be re-examined, all his previous examinations may be cancelled. When a re-examination is necessary owing to the failure of an examination through no fault of the candidates, the cost of such re-examination may be charged to the Special Local Secretary, or to the Managers. A re-examination will not be accepted for the purposes of the Scholarships, &c., mentioned in Part III. of these Regulations.

Board not responsible for mistakes.

62. All possible care is taken to forward the examination papers in accordance with the applications, and to issue the results correctly, but the Board cannot undertake to rectify mistakes, nor will they be responsible for any incidental loss.

PART III.

REWARDS TO STUDENTS AND OTHERS.

CHAPTER 1.

CERTIFICATES, PRIZES, AND MEDALS.

Examination Certificate.

63. A certificate will be issued for each candidate who obtains a success at an examination in any subject.

Exception.—Students in a school recognised under Division A. are ineligible for these Certificates, unless they sit for examination as External Candidates. (*See* Section 30.)

In Honours in Chemistry or Metallurgy the complete Certificate will not be issued until the candidate has been successful in both Theoretical and Practical Examinations. These successes need not necessarily be taken in the same year.

Attendance Certificate.

Certificates of attendance will be supplied to Governors or Managers of schools or classes, who furnish a list on Form 279 of the names of students who have attended during the school-year at least 25 hours' instruction in Stage 1 of a subject under Section 44 of these Regulations for issue to such students.

All the attendances which are to qualify a student for a certificate must have been made under one body of Managers and in a single school-year.

City Guilds Certificate.

The Full Certificates granted by the City and Guilds of London Institute, which are issued to those students who pass the Institute's Examination in Technology (Honours Grade) and have qualified in Science and Art Subjects, will, on the application of the Institute to the Board, be stamped by the Board.

Group Certificate.

On the application of the Governors or Managers a Group Certificate will be issued to a student who for three consecutive years has followed a continuous course of instruction. The whole course of instruction, except in the case of the more advanced work, which may be taken at a place of higher instruction, must as a rule be taken in one recognised school.

63.—(*cont.*)

In Science the course must include practical work in at least one subject in which the student undergoes an examination in theory, and he must obtain a success in Stage 2 or 3 or in Honours of three of the subjects named as competitive of one of the Groups (A., B., C. D., E.) in which subjects are arranged for the National Scholarship Competition. (*See* Section 72.)

In Art the course must provide for such instruction of a student in Drawing, Painting, Modelling, and the History and Principles of Art as leads definitely to some Architectural, Ornamental, or Decorative purpose; and the student must obtain a first class success in at least four of the subjects named as competitive of one of the Groups (A., B., C., D.) in which subjects are arranged for the National Scholarship Competition. (*See* Section 72.)

King's prizes.

64. A small number of King's prizes of books, instruments, &c., are given to those who do best at the local examinations in Art or in Stage 2 or 3 of a Science subject, or in the second or any higher stage of Mathematics; provided that they are eligible to receive them and have made the qualifying number of registered attendances in that subject during the school year in a school under the Board.

The detailed conditions for the award of these prizes (Forms 161 and 161*a*) will be forwarded on application.

Medals.

65. Bronze Medals are given to all candidates who obtain a first class in Honours in a Science subject.

A candidate in Honours in Chemistry or Metallurgy must obtain a first class in both theory and practice before he is eligible to receive a medal.

CHAPTER 2.

Local Science and Art Scholarships.

N.B.—Grants will not be paid by the Board under this Chapter in respect of Scholarships awarded after the year to which these regulations apply.

Local Science and Art Scholarships.

66. Grants to aid the foundation of Local Science and Art Scholarships are made to meet sums provided for the purpose by the contributions of living persons.

Contributions from a rate levied under the Technical Instruction Act, 1889, or under Part II. of the Education Act, 1902, will be held as satisfying the last-named condition.

Contributions from the residue of the moneys vested in Local Authorities under the Customs and Excise Act, 1890; funds derived from endowments or from moneys held in trust, the donor being dead; subscriptions not raised for this definite purpose; and other mere surplus funds, will not be so held.

The Board may refuse to aid any Scholarship for which there is not a sufficient number of competitors, or to appoint a candidate whose financial circumstances do not appear to warrant such aid.

Conditions.

67. The Local Science and Art Scholarships are for competition among the pupils of an Elementary school or schools, or pupils in the Elementary Course of a school conducted under Division A of these Regulations, and must be awarded on the following conditions:—

a. With any number of students up to 100 on the register of the school or group of schools there can be but two such Scholarships; above 100 and up to 150, three; above 150 and up to 200, four Scholarships, and so on.

b. The Scholarship or Scholarships must be awarded in a *bonâ-fide* competition, or on such other conditions as may be specially approved by the Board, to the most successful student or students in some examination of the school. The terms of the competition and the award of the Scholarship will be left to the Governors or Managers of the school, subject to the approval of the Board.

c. The scholar must, at the time of first appointment, be under 16 years of age on the 1st May in the year in which his appointment to a scholarship is made.

d. The teacher, pupil-teacher, or other paid servant of a school is not eligible.

e. The scholar must continue to attend the approved day school regularly while the school is open during a period of twelve months ending 31st July (in a School under Division A the scholarship year will be coincident with that of the School), and—

f. In his first year and in each succeeding year during which he holds his Scholarship, he must be presented at the May or June examinations in one or more subjects of Science or of Art, and show by the results he obtains that he has made satisfactory progress, or, in the case of a Scholarship held in a Secondary School, must satisfy the Board as to his progress.

Object of Scholarships.

68. The object of the Scholarship is to enable the Managers of the local fund to assist the successful competitor in pursuing his studies for one, two, or three years at a day school in which the Board are satisfied that more advanced instruction is given. These Scholarships are not tenable in any Public Elementary School.

Contributions by locality and the Board.

69. The Managers of the local fund must contribute 5*l.* each year in respect of each scholar, and lodge that sum annually with the Board before 5th April. For the first year of tenure of the Scholarship, the local contribution will be supplemented by the Board with a grant of 4*l.*; for the second year with a grant of 7*l.*; and for the third year with a grant of 10*l.* It will rest with the locality to decide whether the Scholarship shall be tenable for one, two, or three, years.

Method of procedure.

70. Application for the Scholarship must be made on Form 280 before the 5th April (or 5th October*). The examination on which it is awarded must be held, and Form 281 submitting the name of the successful competitor must be sent in, before the 1st August (or 1st January*). One moiety of the local contribution will be paid to the parent or guardian of the scholar, or, where the parent or guardian has given his consent in writing, to the local Authority contributing to the Scholarship by the Board shortly after the 1st September (or 1st February*), on the receipt of a certificate (Form 1066) from the Managers that he is making satisfactory progress. The other moiety will be paid in the same way after the 1st February (or 1st July*). The Board's grant becomes due after the end of the Scholarship year, provided that the conditions of the Scholarship have been fulfilled. Application for its payment must be made on Form 282.

Should it be desired to continue the Scholarship for a second or third year, application must be made on Form 473 as soon as the Board's Grant for the preceding year has been paid, and not later than the 1st September.

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* These dates apply only in the case of Scholarships held in Schools under Division A of these Regulations, the school year of which terminates on 31st December.

CHAPTER 3.

Other Grants and Rewards.

71. The following grants and privileges are allowed to teachers and others :—

Grants and Privileges to Teachers and others.

a. Short course of instruction in Science or Art for a limited number of Science Teachers, Art Teachers, and Advanced Art Students are given in the Royal Colleges of Science and Art during July or August.

Only those are eligible for admission to a course who are recognised as qualified to teach the subject or subjects of the course.

The selected candidates will receive third class railway fare for one journey to and fro between their homes and the college, and 3*l.* towards their expenses while attending the courses. In the case of teachers or students resident in London or its vicinity a reduction is made in the grant.

Information as to the precise period of these courses is circulated to Schools about April, and forms of application for admission are sent to Secretaries of Boards of Managers for circulation to the teachers.

b. Science teachers who are sent abroad, or who travel in the service of the Board, receive 10*s.* a night while required to be absent from home, second-class railway fare, and cab or omnibus fares.

c. Aid is granted to a limited number of teachers engaged in science teaching who are selected to attend instruction at Provincial Science Colleges. Particulars of the courses of instruction and of the nature and conditions of the Board's assistance will be sent on application.

d. Grants will be made to enable a limited number of masters and students of Schools of Art and Art Classes to see the works in the National Competition exhibited at South Kensington; to visit and study in the Victoria and Albert Museum, the Royal College of Art, and other Institutions, and, in special cases, Foreign Towns, Schools, and Galleries; to study and make sketches of buildings and of objects in museums; or to study in any approved centre of Art instruction. They may be required to do special work for the Board.

Application must be made on Form 1178 not later than 30th June.

Teachers and Students may be allowed third class railway fare and not more than 7*s.* 6*d.* a night while required to be absent from home. Cab or omnibus fares are allowed only when journeys are made in the service of the Board; and then second class railway fares and 10*s.* personal allowance per night while required to be absent from home may be charged.

e. Any approved Teacher who is actually engaged in teaching or who has recently taught Science or Art classes recognised by the Board, may be permitted to attend, without the payment of any fee, any course of lectures at the Royal Colleges of Science or Art, London, as far as circumstances may allow. Application for this privilege should be made to the Registrars of these Colleges.

71.—(*cont.*)

Facilities will be given to teachers of Science and Art Schools and Classes recognised by the Board, who bring their students to the Victoria and Albert Museum, to examine the collections. When a teacher desires to avail himself of this privilege the Secretary of his school should write to the Board at least one week prior to the intended visit, stating the number of students by whom the teacher will be accompanied, the proposed date and hour of the visit, and the collection which it is desired to inspect. The visits may take place on Mondays, Tuesdays, and Saturdays from 10 a.m. to 9 p.m., and on Wednesdays, Thursdays, and Fridays from 10 a.m. to 4, 5 or 6 p.m., according to the time of the year. Such visits are not allowed on a Bank Holiday. Class-rooms are available for the use of teachers giving Science demonstrations to their students, except in the Southern Galleries, where the Engineering and Naval Architecture Collections are arranged.

Royal Exhibitions, &c.

72. Royal Exhibitions, National Scholarships, Free Studentships and Studentships in Training, tenable for the most part at the Royal College of Science or the Royal College of Art, are awarded by the Board on the results of the Evening Examinations (Section 49). For the conditions of award, *see* the Board's Regulations relating to Museums and Institutions.

APPENDIX A.

REGISTRATION.

General Conditions.

(1.) Governors or Managers may, with the sanction of the Board, adopt any system for the purpose of registration which they may consider convenient, and sufficient to enable them to certify to the correctness of the attendances on which a claim for payment is based, provided that the system does not lend itself to abuse, and has the recommendation of the Inspector. The Governors or Managers must arrange that the system of registration adopted does not curtail the time given to instruction. The absence of a register will be a bar to the payment of a claim.

(2.) The Board may require any register to be forwarded to them. Registers so forwarded will, as a rule, be subsequently returned to the Governors or Managers, but the Governors or Managers before parting with a register should extract any information of which they may have immediate need.

(3.) When the Board are satisfied that, by reason of a notice of the Sanitary Authority of the district in which a school or class is situated, or any two members thereof acting on the advice of the Medical Officer of Health, requiring the Governors or Managers for a specified time, with the view to preventing the spread of disease, or any danger to health likely to arise from the condition of the school or class, either to close the school or class or to exclude any students from attendance, or by reason of any provision of an Act of Parliament, or by reason of the exclusion under medical advice of children from infected houses, the attendance has been seriously diminished, and that consequently a loss of grant would, but for this paragraph, be incurred, the Board have power to make a special grant to the Governors or Managers in respect of students excluded from attendance by the closing of the school or class or otherwise as above, such grant not to exceed that which would be payable on the average registered attendance of the school or class.

Entrance Register.

Entrance Register.

(4.) Governors or Managers are required to keep an entrance register, which must show for each student the full name, age (years and months), occupation, address, and date of joining the school or class. A record of the fees paid by each student must also be kept in such a form as may be approved by the Inspector.

Attendance Register.

(*i.*) *Divisions A and B.*

Attendance Register.

(5.) Special attendance registers will, for the present, be supplied for the use of schools recognised under Divisions A and B, and must be kept in accordance with the regulations printed on them. The provisions of paragraph 12 *infra* are applicable to schools under Divisions A and B.

(*ii.*) *Science and Art Day Classes.*

(6.) A model form of register for recording attendances of students will be sent on application to the Board, but the Governors or Managers must themselves provide the necessary registers for actual use.

The name of the school, the subject of instruction, the name of the teacher, the day, hour, and duration of the lesson must appear on the face of each attendance register. There should also be a space on which the Governors or Managers may, by their dated signatures, record the visits paid by them to the classes, and the number of students then actually present.

(7.) The registration of the attendances made in each school year must be kept distinct.

(8.) The attendance of a student must be registered before the lesson commences, unless a special system of registration has been sanctioned, or unless the mode of registration stated in the exception in paragraph 10 is adopted. No lesson may be registered which is less than one hour in a subject of art, and of less than forty minutes for a lesson in theory, and ninety minutes for a lesson in practical work in mathematics or science.

(9.) The attendance in each subject, and in each stage or section of such subject, must be entered in a separate register. In classes in mathematics or science the separate registration of each subject is only necessary

when a claim for payment on the results of examination in such subject is to be made.

(10.) The presence of each student at a lesson must be definitely marked in the column devoted to that lesson by a stroke /, and his absence by a circle O. Immediately the attendance has been marked for any meeting the total number of students present at that meeting must be entered at the foot of the proper column in the register. The registration of students who leave before the completion of a lesson must be cancelled by drawing a circle round the attendance mark /, thus Ø.

Exception.—In classes in a subject of art the attendances of Students must be recorded by entering against the names, in the column devoted to the meeting of the class, the time in hours and half-hours that each student was actually present under instruction. With the special sanction of the Inspector the attendances of Students may be similarly recorded in classes for Practical Work, in Mathematics, and in Science Subjects II., III., and IV.

(11.) At the end of each course the following totals must be entered—the number of hours attended by each student, the total number of students who make the minimum number of attendances, and the total number of hours made by all these students.

(12.) Visits of students to Galleries, Museums, or other institutions, or places connected with their work, or their attendance for field work, may be recorded in the attendance register, and counted as attendances for grants, if the students are accompanied by the recognised teacher of the class, and all the arrangements are previously submitted to, and approved by the Inspector. At least a week's notice of the intended visit must be given.

(13.) All the entries must be made in ink. Blanks and erasures are not permitted. If any error in the registration is made, it should be corrected by striking through the original entry, so that both the original and the corrected entry appear in the register.

APPENDIX B.

Form 90.

TIME TABLE OF EVENING SCIENCE AND ART EXAMINATIONS IN APRIL, MAY, AND JUNE, 1904.

1904.		ART.
30th April, Saturday	6 to 7.30 p.m. 8 to 10 p.m.	GEOMETRICAL DRAWING. PERSPECTIVE.
2nd May, Monday	7 to 10 p.m.	PRINCIPLES OF ORNAMENT.
3rd „ Tuesday	10 a.m. to 4 p.m. (See *Note* below.) 7 to 9 p.m.	PAINTING FROM STILL LIFE. DRAWING THE ANTIQUE FROM MEMORY.
4th „ Wednesday	7 to 9.30 p.m. 7 to 9 p.m.	FREEHAND DRAWING in Outline. DRAWING OF COMMON OBJECTS FROM MEMORY.
5th „ Thursday	7 to 10 p.m.	DRAWING IN LIGHT AND SHADE from a Cast.
6th „ Friday	7 to 9.30 p.m.	MODEL DRAWING.
7th „ Saturday	5 hours (between 10 a.m. & 10 p.m.)	DRAWING FROM LIFE, including one hour for Drawing from Memory, and an interval of one hour between the time for collecting the drawings made from the Model, and the time for the commencement of the Drawing from Memory. (*The five hours must be consecutive and the same for all Candidates attending at the same centre.*)
9th „ Monday	6 to 10 p.m.	DRAWING FROM THE ANTIQUE.
10th „ Tuesday	7 to 10 p.m.	ANATOMY.
11th „ Wednesday	6 to 10 p.m.	DESIGN, Stage 1, Stage 2, and Honours.
12th „ Thursday	7 to 10 p.m.	HISTORIC ORNAMENT.
13th „ Friday	6 to 10 p.m.	PAINTING ORNAMENT.
14th „ Saturday	6 to 10 p.m.	ARCHITECTURE.
16th „ Monday	7 to 9 p.m.	MEMORY DRAWING OF PLANT FORM.

1904.		ART.
17th May, Tuesday and 18th „ Wednesday	6 to 10 p.m. 8 hours (between 10 a.m. & 10 p.m.) (See *Note* below.)	MODELLING THE HEAD FROM LIFE. For Candidates to CAST THEIR CLAY MODELS. (*The eight hours must be consecutive and the same for all Candidates attending at the same centre.*)
16th „ Monday to 19th „ Thursday and 20th „ Friday	6.30 to 10 p.m. (Each evening.) 8 hours (between 10 a.m. & 10 p.m.) (See *Note* below.)	MODELLING FROM THE ANTIQUE. For Candidates to CAST THEIR CLAY MODELS. (*The eight hours must be consecutive and the same for all Candidates attending at the same centre.*)
30th „ Monday to 1st June, Wednesday	4 to 10 p.m. (See *Note* below.)	ARCHITECTURAL DESIGN.
2nd „ Thursday and 3rd „ Friday and 4th „ Saturday	6.30 to 10 p.m. (Each evening.) 8 hours (between 10 a.m. & 10 p.m.) (See *Note* below.)	MODELLING DESIGN (Stage 2 only). For Candidates to CAST THEIR CLAY MODELS. (*The eight hours must be consecutive and the same for all Candidates attending at the same centre.*)
6th „ Monday to 10th „ Friday and 11th „ Saturday	6.30 to 10 p.m. (Each evening.) 8 hours (between 10 a.m. & 10 p.m.) (See *Note* below.)	MODELLING FROM LIFE. For Candidates to CAST THEIR CLAY MODELS. (*The eight hours must be consecutive and the same for all Candidates attending at the same centre.*)
13th „ Monday. to 16th „ Thursday and 17th „ Friday	6.30 to 10 p.m. (Each evening.) 8 hours (between 10 a.m. & 10 p.m.) (See *Note* below.)	MODELLING DESIGN. (Honours). For Candidates to CAST THEIR CLAY MODELS. (*The eight hours must be consecutive and the same for all Candidates attending at the same centre.*)

Note.—On the 3rd, 30th, and 31st May and 1st June the six hours include half an hour for refreshment. On the 3rd May the half hour

must be taken by all Candidates from 1 to 1.30 p.m. On the other dates the half hour each evening must be taken by all Candidates from 7 to 7.30 p.m. The eight hours, including half an hour for refreshment, for casting on the 18th and 20th May, and 4th, 11th, and 17th June, may be taken as convenient in the morning and afternoon, or the afternoon and evening of each day.

1904.	p.m.	SCIENCE.
30th April, Saturday	6 to 10	I.—Practical Plane and Solid Geometry.
	7 to 10	XXIV.—Agricultural Science and Rural Economy, (Division I.) Stage 1 and Stage 2.
2nd May, Monday	7 to 10	VI*a*.—Theoretical Mechanics. —Solids, Stage 1 and Stage 2 only.
3rd „ Tuesday	7 to 10	VII.—Applied Mechanics. XIV.—Human Physiology.
4th „ Wednesday	7 to 10	XVIII.—Principles of Mining. XXIV.—Agricultural Science and Rural Economy, Stage 2 (Division II.) and Honours. The examination in Stage 1 (Division II.) will be the same as that in the Alternative Stage 1 of Theoretical Inorganic Chemistry, and will be held, as shown below, on 16th May from 7 to 10 p.m.
5th „ Thursday	7 to 10	VI*b*.—Theoretical Mechanics. Fluids, including Stage 3 and Honours in Solids and Fluids. XX.—Navigation and Stage 3 and Honours in Navigation and Spherical and Nautical Astronomy. XII.—Geology.
6th „ Friday	7 to 10	VIII*c*.—Heat, Stage 2, Stage 3, and Honours. XVI.—Zoology.
7th „ Saturday	6 to 10	III.—Building Construction.
9th „ Monday	7 to 10	XXIII.—Physiography. XIX.—Theoretical Metallurgy, including the written examination in Honours of Metallurgy.
10th „ Tuesday	7 to 10.30	V.—Mathematics, Stages 1, 2, 3, 4, and Honours in Division I.
11th „ Wednesday	7 to 10	VIII*b*.—Light, Stage 2, Stage 3, and Honours. XV.—General Biology.
12th „ Thursday	7 to 10	IX.—Magnetism and Electricity.

1904.	P.M.	SCIENCE.
13th May, Friday	7 to 10	VIII.—SOUND, LIGHT, AND HEAT, Stage 1. VIII*a*.—SOUND, Stage 2, Stage 3, and Honours.
14th „ Saturday	6 to 10	II.—MACHINE CONSTRUCTION AND DRAWING. IV.—NAVAL ARCHITECTURE.
16th „ Monday	7 to 10	X.—THEORETICAL INORGANIC CHEMISTRY, including alternative Elementary Chemistry and Honours of Chemistry, Organic and Inorganic.
17th „ Tuesday	7 to 10	XI.—THEORETICAL ORGANIC CHEMISTRY. XXII.—STEAM.
18th „ Wednesday	7 to 10	V.—MATHEMATICS, Stages 5, 6, 7, and Honours in Division II. XXV.—HYGIENE.
19th „ Thursday	2.30 to 10.30	XI*p*.—PRACTICAL ORGANIC CHEMISTRY. Stage 1 - Written, 6 to 7 p.m. Practical, 7.15 to 9.30 p.m. Stage 2 - Written, 6 to 7 p.m. Practical, 7.15 to 10.30 p.m. Stage 3 - 2.30 to 10.30 p.m.
20th „ Friday	7 to 10	XVII.—BOTANY. V*p*.—PRACTICAL MATHEMATICS, Stage 1, Stage 2, and Stage 3.
30th „ Monday	7.15 to 9.30	X*p*.—PRACTICAL INORGANIC CHEMISTRY, Stage 1.
31st „ Tuesday	2 to 10	XIX*p*.—PRACTICAL METALLURGY. Stage 1, 6 to 10 p.m. Stage 2, 5 to 10 p.m. Stage 3, 2 to 10 p.m.
1st June, Wednesday	6 to 9	XIII.—MINERALOGY. XXI.—SPHERICAL AND NAUTICAL ASTRONOMY, Stage 1 and Stage 2.
4th „ Saturday	2.30 to 10.30	X*p*.—PRACTICAL INORGANIC CHEMISTRY, Stage 2 and Stage 3. Stage 2 - Written, 5.15 to 6.15 p.m. Practical, 6.30 to 10.30 p.m. Stage 3 - 2.30 to 10.30 p.m.

The examinations in Drawing on the Blackboard are held during April, May, and June. Application for admission to the examinations in this subject must be made to the Secretary of an approved centre

not later than 1st March (for the special conditions affecting these examinations *see* Section 57 (*d*) of the Regulations).

In laboratories where the Board has sanctioned the practical examination in two divisions, the times for the first division will be as follows:—Inorganic Chemistry, Stage 1, 3.30 to 5.45 p.m.; Stage 2, 1 to 5 p.m. Organic Chemistry, Stage 1, 3.30 to 5.45 p.m.; Stage 2, 2.30 to 5.45 p.m. The practical examination for the second division in the respective stages, and in the case of Stage 2 of X*p*. and Stages 1 and 2 of XI*p*., the written examination for both divisions will be held at the times stated in the time table above.

In Practical Metallurgy there will be, for all stages, a practical examination only. Where the Board has sanctioned the examination in Stage 2, or Stage 1 in two divisions, the examination of the first division will be held from 10 a.m. to 3 p.m. for Stage 2, and from 1 to 5 p.m. for Stage 1. The examination for the second division will be held at the times stated in the time table above.

In Science subjects in which Honours includes both a written and a practical examination, the examination papers to be set on above dates will include the questions for the written examination only. The dates of the practical examinations at South Kensington will be communicated to qualified Candidates in due course afterwards. The examination in Honours of Practical Chemistry will be held about June at appointed centres, and will extend over three or more days. The precise dates and places of examination will be subsequently announced.

APPENDIX C.

Form 90*d*.

TIME TABLE OF DAY SCIENCE AND ART EXAMINATIONS, JUNE, 1904.

These Examinations are confined to the Subjects and Stages specified. They do not include Papers in Stage 3 or Honours, and marks gained in them do not count in the Competition for Royal Exhibitions, National Scholarships, or Free Studentships; or for Whitworth Scholarships and Exhibitions; or for Royal Exhibitions and Local Scholarships (Art).

1904.

Monday, 13th June.	10 a.m. to 1 p.m.	Art.	- -	- Drawing in Light and Shade from a Cast.
	2 to 5 p.m.	Science.	Subject XXIV.	Agricultural Science and Rural Economy, Division I., Stage 1 and Stage 2.
Tuesday, 14th June.	10 a.m. to 12.30 p.m.	Art	-	Model Drawing.
	2 to 4.30 p.m.	„	-	Freehand Drawing in Outline.
Wednesday, 15th June.	10 to 11.30 a.m.	„	-	Geometrical Drawing.
	12 to 2 p.m.	„	-	Perspective.
	10 a.m. to 2 p.m.	Science.	Subject I. -	Practical Plane and Solid Geometry, Stage 1 and Stage 2.
	3 to 6 p.m.	„	„ XXIV.	Agricultural Science and Rural Economy. Division II., Stage 2. The Examination in Stage 1 (Division II.) will be the same as that in the Alternative Elementary Stage of Theoretical Inorganic Chemistry, and will be held, as shown below, on 20th June, from 10 a.m. to 1 p.m.
Thursday, 16th June.	10 a.m. to 1 p.m.	„	„	VIII. Sound, Light, and Heat, Stage 1.
			„	VIII*a*. Sound, Stage 2.
	2 to 5 p.m.	„	„	VI*a*. Theoretical Mechanics (Solids), Stage 1 and Stage 2.
Friday, 17th June.	10 a.m. to 1 p.m.	„	„	VIII*c*. Heat, Stage 2.
	2 to 5 p.m.	„	„	IX. Magnetism and Electricity, Stage 1 and Stage 2.
Saturday, 18th June.	10 a.m. to 1 p.m.	„	„	VI*b*. Theoretical Mechanics (Fluids), Stage 1 and Stage 2.
	2 to 5 p.m.	„	„	VIII*b*. Light, Stage 2.

1904.

Monday, 20th June.	10 a.m. to 1 p.m.	Science.	Subject X.	Theoretical Inorganic Chemistry, Stage 1, Alternative Stage 1 and Stage 2.
	2 to 5 p.m.	„	„ XIV.	Human Physiology, Stage 1 and Stage 2.
Tuesday, 21st June.	10.30 a.m. to 12.45 p.m.	„	„ X*p*.	Practical Inorganic Chemistry, Stage 1 (10.30 a.m. to 12.45 p.m.)
	3 to 6 p.m.	„	„ XII.	Geology, Stage 1 and Stage 2.
			„ V.	Mathematics, Stages 5, 6, and 7.
Wednesday, 22nd June.	10 a.m to 1 p.m.	„	„ V.	Mathematics, Stages 1, 2, 3, and 4.
	2 to 5 p.m.	„	„ XXV.	Hygiene, Stage 1 and Stage 2.
Thursday, 23rd June.	10 a.m. to 1 p.m.	„	„ XVII.	Botany, Stage 1 and Stage 2.
	2 to 5 p.m.	„	„ XXIII.	Physiography, Stage 1 and Stage 2.
Friday, 24th June.	9.15 a.m. to 2.30 p.m.	„	„ X*p*.	Practical Inorganic Chemistry, Stage 2. (Practical 9.15 a.m. to 1.15 p.m.; Written, 1.30 to 2.30 p.m.)
	3 to 6 p.m.	„	„ XV.	General Biology, Stage 1 and Stage 2.

The examinations in Drawing on the Blackboard are held during April, May, and June. Application for admission to the examinations in this subject must be made to the Secretary of an approved centre not later than 1st March (for the special conditions affecting these examinations see Section 57 (*d*) of the Regulations).

In laboratories where the Board have sanctioned the practical examination in two divisions, the second division in Stage 2 will be examined from 2.45 to 6.45 p.m., and in Stage 1 from 2.15 to 4.30 p.m. The practical examination for the first division, in the respective stages, and in the case of Stage 2 the written examination for both divisions, will be held at the times stated in the time table above.

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(From 1st AUGUST 1903 to 31st JULY 1904.)

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MEMORANDUM.

These Regulations supersede those for the year 1902–1903.

A separate volume is issued containing **Syllabuses** and **Lists of Apparatus.**

The divisions in Science and Art Subjects other than Mathematics (Subject V.), formerly described as Elementary Stage and Advanced Stage, are now described as Stage 1 and Stage 2 respectively, and the divisions in Science subjects, formerly known as Honours, Part I., and Honours, Part II., are replaced by divisions described as Stage 3 and Honours respectively.

Copies of any of the forms referred to in the Regulations will be supplied on application, personally, or by letter addressed to The Secretary, Board of Education, South Kensington, London, S.W.

Official communications should be written upon foolscap paper and sent in envelopes addressed to The Secretary, Board of Education, South Kensington, London, S.W. The postage need not be prepaid, and it is particularly requested that Post Cards and Correspondence Cards may not be used.

Telegraphic Address: "Instruction, London."

A Circular Letter respecting this Volume of Regulations is being issued by the Board of Education, and a copy of it will be forwarded to Managers of Schools and others on application.

July 1903.

Regulations for Evening Schools, Technical Institutions, and Schools of Art and Art Classes.

PART I.

GRANTS.

Preliminary.

1. The conditions required to be fulfilled by any Evening School, Technical Institution, School of Art, or Art Class, herein-after called "the School," in order to obtain a grant from the Board of Education, herein-after called "the Board," are those contained in the following Regulations.

The decision of the Board as to whether these conditions have been fulfilled in any case is conclusive.

No grant is payable under these Regulations for any Public Elementary School, Secondary School, Pupil-teacher Centre or Training College for teachers in elementary schools.

CHAPTER 1.

General Conditions of Grant.

Management.

2. (*a.*) The School must be superintended by a responsible body of Managers, to whom, subject as herein-after provided, the grant will be paid; and there must be a person appointed to act as correspondent on behalf of the Managers.

(*b.*) In the case of any School working under the direction of the Council of any County or County Borough, the grant will be paid to the Council, and the correspondent will be appointed by the Council.

(*c.*) The body of Managers must include at least one person able frequently to visit the School.

Religious instruction.

3. (*a.*) A scholar attending as a day or evening scholar shall not be required, as a condition of being admitted into or remaining in the School, to attend or abstain from attending any Sunday School, place of religious worship, religious observance, or instruction in religious subjects in the School or elsewhere; and

(*b.*) The times for religious worship or for any lesson on a religious subject shall be conveniently arranged for the purpose of allowing the withdrawal of any such scholar therefrom.

Eligibility of students.

4. No student may be registered for the purposes of grant under these Regulations (1) who is under 12 yea of age, or (2) on account of whom any grant is paid the Board of Education under any other Regulations.

For the year ending 31st July 1904, the last-mentioned restricti will not apply in the case of any student on account of whom a grant paid under the Board's Regulations for the instruction and training pupil teachers.

Year.

5. The term "year" in these Regulations means t twelve months ending the 31st July.

Application for recognition.

6. The School will not, as a rule, be placed upon the lis of recognised Schools except upon an application mad in each year to the Board on the Form, and by the dat prescribed in Chapter 2, 3, or 4, as the case may be.

Inspection.

7. The School must be open at all reasonable time to inspection by the officers of the Board, who wi ascertain, in such manner as may be necessary, whethe the conditions of grants, as set forth in these Regula tions, are fulfilled, and will report thereon to the Board

A deduction from the grant not exceeding 1*l.* may b made if the Inspector finds any class closed at a tim when the time-table provides for instruction being give

School not to be unnecessary.

8. The School must not be unnecessary, and must n unduly compete with any other School.

Before recognising as eligible for a grant unde these Regulations any School not already in recei of a grant, the Board will, as a rule, invite the opinio of the County or County Borough Council on the questio of the necessity of such School, and will have regard the co-ordination of all forms of education in the area the Council.

Character of School.

9. The School must be suitable in character an financial position to receive aid from the Board's gran and must not be conducted for private profit, or farme out to the teacher.

For the year ending the 31st July 1904, the grant will not be wit held under this Section from any School managed by a public compan in the Articles of Association of which provision is made that no divide shall be paid exceeding 5 per cent. per annum, if the School is alrea in receipt of a grant.

Admission of students.

10. No student may be refused admission on othe *than* reasonable grounds.

11. The fees must be suitable to the circumstances of the locality, and must be approved by the Board. Fees.

Where the Managers desire either to charge no fees or to remit the fees to individual students, the previous sanction of the Board must be obtained.

12. The School must have adequate local support. At least 25 per cent. of the expenditure of the School, or group of Schools under the same Managers, or under the direction of the same County or County Borough Council, should be met from sources other than the Board's grant, such as fees, subscriptions, grants from the local authority, or endowments. Local support.

13. The grant must be expended to the satisfaction of the Board, and an account of income and expenditure must be rendered annually in such form as the Board may require. Income and expenditure.

14. The registration of students must be conducted in accordance with the rules contained in Appendix A. to these Regulations. Registration.

15. All returns called for by the Board must be duly made, and must be trustworthy. Returns.

16. The School must be efficient, and the progress of the students must be satisfactory. School to be efficient.

17. The premises must be sanitary, convenient for teaching purposes, adapted to the circumstances of the School, and provided with satisfactory equipment and appliances. Premises and equipment.

18. The Teaching Staff must be sufficient and efficient, and the teachers must possess such qualifications as may be required by the Board. Sufficiency and qualification of teaching staff.

For further information respecting the qualifications of teachers, *see* Appendix B.

19. The teachers must, as a rule, be paid by fixed salaries, and their employment at other times must not be such as will prevent the efficient discharge of their duties as teachers. Payment and employment of teachers.

20. The course of instruction must be suitable to the circumstances of the locality, and must be approved by the Board. Course of instruction.

Arrangements should be made, so far as practicable, to provide for a progressive course or courses of instruction for students attending in successive years.

Syllabus.

21. The Syllabus must be approved by the Board.

Syllabuses of subjects in which the Board hold examinations, and specimen syllabuses of instruction in certain other subjects, are published in a separate volume.

Preliminary training of students.

22. No student may be admitted to any course who, from want of sufficient preliminary training, or other cause, is not qualified to take advantage of the instruction given in it. The grant may be withheld on account of students in any course whom the Inspector reports to be thus unqualified.

Epidemic illness.

23. No grant will be paid in respect of any attendances lost, or on account of any period during which the school is closed for epidemic illness, but where the Board are satisfied that any failure to comply with the conditions of Sections 28, 29, 40, 41, 45, or 49, has been due to epidemic illness or other unavoidable cause, they may relax the conditions of those sections so far as may be necessary to meet the case.

Revision of grant.

24. If any of the conditions on which the grant is awarded are not fulfilled, the Board may withhold the grant, or, if they think fit, may pay the grant with or without deductions, warning the Managers that a grant will not again be paid under similar circumstances.

CHAPTER 2.

Conditions of Grant specially applicable to Evening Schools.

Time of meetings.

25. The grant will, as a rule, only be payable in respect of instruction given after 4 p.m., or on Saturdays after 1 p.m.

Exception.—In special circumstances a grant may be allowed in respect of instruction given at an earlier hour, if the previous sanction of the Board has been obtained.

Time-table.

26. Application for recognition must be made to the Board on Form 125 before the 1st October in each year, and the time-table, which must be submitted to the Inspector in duplicate on Form 125*a*, must show the subject or subjects in which instruction is given, and the days and time allotted to each subject. At least a week's previous notice of any alteration in the time-table affecting the days or hours of meeting or of a holiday or temporary closure of any class must be given to the *Inspector*. The Managers must also give a clear

26.--(*cont.*)
fortnight's notice to the Inspector of the date at which any class will close for the year.

Short courses.

27. Applications for the recognition of short courses in special subjects may be accepted at a later date than that named in Section 26, provided that the applications are received by the Board at least one month before the course begins.

Minimum length of course.

28. No grant will be made for instruction in any subject or course in which less than 20 hours of instruction is given in the year.

Where it is necessary on educational grounds to hold some of the meetings of a class before, as well as after, the 31st July in any year, the Board may allow the meetings of such a class to be carried forward to the following year, provided that no grant will be made in respect of any subject in which less than 20 hours of instruction in all has been given.

Minimum attendance of student.

29. No student's attendance in any course may be counted unless he has received at least 14 hours of instruction in that course in the year.

Where students become eligible for registration too late to receive 14 hours' instruction in any course before the 31st July in any year, the Board may allow the attendances of such students to be carried forward to the following year, provided that no grant will be made in respect of a student who receives in all less than 14 hours' instruction in that course.

Maximum attendance of student.

30. Not more than 160 hours of instruction in a school may be counted for any student in one year.

Assessment of grant.

31. The rates payable under Sections 32 and 33 will be determined by the Board upon the Inspector's Report, and other evidence as to the circumstances and work of the school.

Subjects and grants.

32. Subject to the foregoing conditions, a grant may be paid for each complete 20 hours of instruction received by registered students in an authorised subject or course of instruction at one of the rates applicable to the Division in which the subject or course is included.

The subjoined lists show the arrangement of the leading subjects in Divisions for the purposes of this section, but subjects other than those given in the different divisions may be approved should the Board

32.—(*cont.*)

consider them to be of educational value and suited to the needs of the locality.

DIVISION I.—LITERARY AND COMMERCIAL.

Reading, Writing, and Arithmetic—either taken separately or in any combination.
Knowledge of Common Things, or Nature Knowledge.
Elementary Drawing.
English.
Latin.
Life and Duties of a Citizen.
Commercial Correspondence and Office Routine.
Book-keeping.
Shorthand.
Vocal Music, if including instruction in theory of music.
*Geography and History—either taken separately or together.
*Economics.
*Mercantile Law and Practice.
*French.
*German.
*Any other Modern Language.

The rate of grants payable will, as a rule, be from 2*s.* 6*d.* to 3*s.* 6*d.*

The rate of grant may be increased up to 5*s.* where advanced instruction is efficiently given, by teachers recognised as qualified by the Board, in any of the subjects marked with an asterisk, and where the syllabus followed is one of the Specimen Advanced Syllabuses published by the Board or a corresponding syllabus specially approved for the purpose by the Board.

Where a School proposes to claim the higher rate of grant for any of these subjects, notification must be given to the Board before the commencement of the course.

No lesson of less than one complete half-hour will be allowed to count as instruction in the above subjects.

DIVISION II.—ART.

The ordinary rate of grants will be from 2*s.* 6*d.* to 3*s.* 6*d.*

32.—(*cont.*)

This rate may, however, be increased up to 15*s.* according to the efficiency of the instruction and equipment, the qualifications of the teachers, and the work submitted for the National Competition. (*See* Section 70 of these Regulations.)

Where the instruction in Art is arranged with definite relation to the requirements of a particular craft, or group of crafts, and includes practical instruction in the craft-methods necessary to illustrate corresponding systematic instruction in drawing, modelling, or design, the rate of grant will depend upon the extent to which the course is concerned with principles and their application, as distinct from practice in a craft with a view to the acquirement of manipulative skill.

For the hours of a student's instruction between 60 and 160, the grant will be payable only at the ordinary rate.

No lesson of less than one hour will be allowed to count as instruction in Art.

Division III.—Manual Instruction.

Wood-work.
Metal-work.

The rate of grants payable will, as a rule, be from 2*s.* 6*d.* to 3*s.* 6*d.*

When special equipment has been provided, the rate may be increased, in the case of Wood-work up to 4*s.*, and in the case of Metal-work up to 5*s.*

Manual instruction must, as a rule, be connected with instruction in drawing, that is to say, the work must be from drawings to scale previously made by the scholars.

Manual instruction in Metal-work may include instruction in the use of machine-tools, but no course can be approved which does not secure adequate training in the use of hand-tools. The course may be arranged so as to form a preliminary training for engineering trades in general; it must not be specialised so as to be applicable only to a single branch of trade.

32.—(*cont.*)

No lesson of less than one hour will be allowed to count as instruction in the above subjects.

Division IV.—Science.

Any generalised or special branch of Science, including Mathematics, will be accepted, if a suitable syllabus is submitted.

The ordinary rate of grants payable will be from 2*s.* 6*d.* to 3*s.* 6*d.*

This rate may be increased for Elementary work up to 8*s.* 6*d.*, and for Advanced work up to 20*s.* according to the efficiency of the instruction and equipment, the experimental illustration of the teaching, and the qualifications of the teacher.

For systematic practical instruction given under the same conditions, and in lessons of not less than one hour and a half in an approved laboratory, grants up to 13*s.* and 25*s.* respectively may be awarded.

The works submitted for the National Competition by the students in classes in Science subjects II., III., and IV., may be taken into account in assessing the rates of grant for attendances in such classes.

Where the instruction in Science is arranged with definite relation to the requirements of a particular trade, or group of trades, and includes practical instruction in the trade-methods necessary to illustrate corresponding systematic instruction in the underlying scientific principles, the rate of grant will depend upon the extent to which the course is concerned with principles and their application, as distinct from practice in trade-processes with a view to the acquirement of manipulative skill.

For the hours of a student's instruction between 120 and 160, the grant will be payable only at the ordinary rate.

No lesson of less than 40 minutes will be allowed to count as instruction in the theory, or of less than 1½ hours in the practical work of the above subjects.

32.—(*cont.*)

DIVISION V.—HOME OCCUPATIONS AND INDUSTRIES.

Needlework.
Domestic Economy.
Cookery.
Dressmaking and Cutting Out.
Laundry-work.
Dairy-work.
Gardening.
Cottage Industries.
Ambulance.
Home Nursing.

The rate of grants payable will, as a rule, be from 2*s.* 6*d.* to 3*s.* 6*d.*

Where experimental or practical work is satisfactorily carried out in subjects, other than Needlework, involving exceptional expenditure for materials and appliances, grants up to 5*s.* 6*d.* may be made.

No lesson of less than one hour will be allowed to count as instruction in the above subjects.

Organized Courses.

33. Where the equipment of the School, the qualifications of the teachers, and the standard of general education of the students permit, a course of organized instruction including subjects from any one or more of the Divisions specified in Section 32 may be submitted for the approval of the Board.

The course must be arranged with a view to the occupations of the students. It must extend over a period of not less than four years, and no student may be admitted to the second or any later year of the course who is not qualified by his progress in the work of the preceding year, or by a corresponding standard of attainment.

Classified lists of the students for whom a grant is to be claimed under this Section must be furnished to the Board before the 1st December in each year.

In the case of any student taking a course approved under this Section the limitation to the rate of grant payable on the hours of his instruction between 120 and 160, mentioned in Division IV. of Section 32, will not apply.

Grant on results of Examinations.

34. The following grant may be made on the Results of the Examination of students who have received during the School year at least twenty registered lessons in each subject in respect of which the grant is claimed, each lesson to be of an hour's duration in the case of an Art subject or of a theoretical subject of Science, and of an hour and a half's duration in a practical subject of Science:—

(*a.*) 3*l.*, 2*l.*, and 1*l.* for an excellent, first class, or second class respectively in Drawing and Modelling from the Life and Architectural Design.

(*b.*) 6*l.* and 3*l.* for a first or second class respectively in Honours.

(*c.*) If the student, on account of whom the grant under (*a*) or (*b*) is claimed, has been previously successful in the same subject, or in a corresponding subject, the grant on his account will be reduced by the grant which would be payable on such previous success; but when such previous success has been obtained in a school or class under the same Managers, and no grant has been made for it, the Board may allow the full claim. Grants for not more than three successes, whether in Honours or in Drawing from Life or Modelling from Life or Architectural Design, will be allowed for the same student in the same year.

CHAPTER 3.

Conditions of Grant specially applicable to "Technical Institutions."

"Technical Institutions."

35. An Institution giving an organised course of instruction in day classes, including advanced instruction in Science, or in Science and Art, and provided with a staff and equipment adequate for the purpose, may be recognised as a "Technical Institution," and grants may be made to any Institution so recognised under the regulations contained in this Chapter.

Application for recognition.

36. Application for original or continued recognition must be made to the Board on the prescribed form before the 1st September in each year, and the course of instruction, the syllabuses of the subjects proposed to be taken, and the time-table, must at the same time be submitted for approval.

37. Provision must be made for at least a two years' systematic course in Science, or in Science and Art, either alone, or in conjunction with subjects of general, commercial, manual, or technological instruction. Character of course.

38. No student may be admitted to the course unless either (1) he has passed through at least a three years' course of instruction in a School recognised under Division A. or Division B. of the Board's Regulations for Secondary Schools; or (2) he is over 15 years of age and is qualified from his general education to profit by a course of advanced instruction. Qualification of student.

39.—(*a.*) No attendance of less than one hour's duration may be registered for any student. Minimum and maximum length of attendance.

(*b.*) Not more than six hours' instruction may be registered for any student on any one day.

40. A uniform grant, not exceeding 120*s.* for the first year's course, and not exceeding 180*s.* for the second and succeeding years' courses, may be paid upon the attendance of each student who receives in the year not less than 600 hours' instruction in an approved course. The rate will be determined by the Board, and will depend on the time allotted to the Science and Art instruction, on the cost of the necessary equipment, and on the report of the Inspector upon the character and efficiency of the instruction as a whole, the manner in which the students have benefited by it, and its suitability to the special circumstances of the locality. Grants.

41. Where a course of the character contemplated in this Chapter is efficiently conducted, grants may also be allowed upon the attendances of students other than those in full-time attendance at the course, provided that— Grants for shortened courses.

(1) the shortened courses taken by such other students are approved by the Inspector as necessary and suitable in the circumstances of each case; and

(2) the presence of such other students does not interfere with the progress of the students in full-time attendance:

A uniform grant at one-third [or two-thirds] of the rate determined by the Board under the last preceding

41.—(*cont.*)

section may be paid upon the attendance of each student who satisfies these conditions and receives not less than 200 [or 400] hours' instruction in the course approved for him in the year.

Grant for part of course.

42. A grant may be allowed at one of the rates mentioned in Section 41 on the attendance of any student who attends for 400 or 200 hours in the year, though registered for a longer course, if he fails to attend the minimum number of hours for such longer course, but receives continuous instruction throughout the period of his attendance.

Subject to this allowance, no grant will be paid for any student who fails to attend for the minimum number of hours mentioned in Sections 40 or 41 in the course approved for him.

Grant under Section 34.

43. In addition to the foregoing grants an Institution recognised under this Chapter is eligible for grants under Section 34 (Chapter 2).

CHAPTER 4.

Conditions of Grant specially applicable to "Schools of Art" and Day Art Classes.

"Schools of Art."

44. An Institution giving an organised course of instruction, including advanced instruction, in Ornamental and Decorative Art, may be recognised as a "School of Art," and grants may be made to any institution so recognised under the regulations contained in Sections 45 to 53.

Meetings.

45. The work of a School of Art must be carried on methodically under the recognised teachers in day and evening classes for about 40 weeks in the year. The day classes must meet on at least two days a week for two hours at each meeting, and the evening classes must meet on at least three evenings a week for two hours at each meeting.

Qualifications of *teachers.*

46. There must be a Principal Teacher holding an Art Master's Certificate (Group I.). Specially qualified

46.—(*cont.*)
persons may be exceptionally recognised. The qualifications of other teachers must be submitted to the Board for their approval.

47. The rooms must be approved by the Board for the purposes of a School of Art, and must be devoted wholly to Art instruction. They should be well lighted for Drawing from Plants and the Life, for Painting and for Modelling, and suited for elementary and other study and instruction in Ornamental and Decorative Art. Premises and curriculum.

48. The Managers must submit in duplicate on Form 134 the time-table and teaching staff for approval, with an outline of the curriculum to be followed, as soon as possible after the 1st August, and not later than the 1st September. Time-table.

49. A Branch School of Art must be under the same Managers as the School of Art of which it is a Branch, and must be in the same district. It must have Evening Classes open three evenings a week for a year of about 40 weeks, and must be taught by a Teacher holding the Art Class Teacher's or a higher Certificate, and acting under the direction of the Principal Teacher of the School of Art, who must supervise the approved course of study and work to be followed at the Branch School. Branch Schools of Art.

50. Schools of Art and Branch Schools must submit works for the National Competition, and also a selection of School Works to illustrate the character of the course of instruction (for detailed conditions, *see* Form 564, which will be forwarded on application). Submission of School Works.

51.—(*a.*) Schools of Art which have been efficient for the last five years will, as a rule, be paid an annual grant equivalent to the average of the amount received by the school for attendances, results, and works for the last three years. This annual grant will remain the same from year to year, subject to any reassessment which may be made upon the result of a detailed inspection, to be held in general at intervals not exceeding three years. Grants.

(*b.*) The grant to other Schools of Art and to all Branch Schools of Art will consist of payments on attendances

51.—(*cont.*)

(*see* Section 32 of these Regulations) and on results of Advanced examinations (*see* Section 34).

Grants for Art Pupil-teacher.

52. In addition to the grant mentioned in Section 51, a grant not exceeding 15*l.* for an Art Pupil-teacher may be made to a School of Art, or Branch School of Art, in which at least 20 Students have been satisfactorily taught; and a further grant not exceeding 15*l.* for a second Art Pupil-teacher, to a School of Art in which there are at least 50 such Students. Students are considered to have been taught satisfactorily when their attendance has been regular, and they have given, at the inspections or examinations, satisfactory evidence of their progress during the year.

Not more than one Art Pupil-teacher may be recognised in a Branch School of Art.

This grant is to assist Managers in training young, deserving, and qualified students to become Teachers, and may not be claimed in respect of members of the Teaching Staff.

The Managers must annually notify on the prescribed Form their nomination of an Art Pupil-teacher for the approval of the Board. The candidate approved by the Board must have passed in Freehand, Geometry, Model, and Perspective Drawing, or have obtained corresponding or higher qualifications at the Art examinations of the Board. The Board will consider proposals to make appointments outside this rule. The Art Pupil-teacher, who must not be required to pay fees for instruction, must during the year of his appointment submit works for examination, or sit for examination in subjects other than those in which he has previously obtained success.

In the case of Branch Schools of Art, fresh nominations of Art Pupil-teachers will only be considered when instruction of an advanced as well as of an elementary character is provided in the Branch both in the day and evening.

No person over 25 years of age may be appointed Art Pupil-teacher. The appointment is from year to year. In no circumstances may the same person be continued as Art Pupil-teacher for more than five years.

An Art Pupil-teachership cannot be held by a Local Scholar.

The claim to a full grant under this article must be supported in each case by the Art Pupil-teacher's receipt for the amount paid to him by the Managers in respect of his services for the school year of 12 months ending July 31st.

Grants for Free Studentship, &c. Special payments.

53. The following further grants may also be made to a School of Art:—

(*a.*) 3*l.* for a student obtaining a Free Studentship tenable at the School (*see* Section 78) or a Local Scholarship (*see* Section 79).

53.—(*cont.*)

(*b.*) 5*l.* for every Student taught in the School who obtains a Royal Exhibition or a National Scholarship, or is admitted as a Student in Training to the Royal College of Art.

The grants under this Section are not payable to a Branch School of Art.

54. The grant for Art Classes meeting in the day-time, other than Classes in a School of Art, is payable on the same conditions as the grant for Art Classes held in Evening Schools (*see* Division II. of Section 32). Grant for Day Art Classes.

PART II.

EXAMINATIONS IN SCIENCE AND ART.

Subjects of examination.

55. Examinations are held by the Board, under the conditions stated in this Part of these Regulations, in the following subjects :—*

(*a.*) Science, including Mathematics.

I. Practical Plane and Solid Geometry.
II. Machine Construction and Drawing.
III. Building Construction.
IV. Naval Architecture.
VII. Applied Mechanics.
XXII. Steam.
V*p*. Practical Mathematics.

V. Mathematics.
VI*a*. Theoretical Mechanics (Solids).
VI*b*. Theoretical Mechanics (Fluids).
XX. Navigation.
XXI. Spherical and Nautical Astronomy.

VIII. Sound, Light, and Heat.
VIII*a*. Sound.
VIII*b*. Light.
VIII*c*. Heat.
IX. Magnetism and Electricity.
XXIII. Physiography (Sec. 1, Stage 1).

X. Inorganic Chemistry.
X*p*. Inorganic Chemistry (Practical).
XI. Organic Chemistry.
XI*p*. Organic Chemistry (Practical).
XIX. Metallurgy.
XIX*p*. Metallurgy (Practical).

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* The "Stages" or other sub-divisions of the subjects in which the examinations are held are those mentioned in the syllabuses on which the papers set at the examinations are based. These syllabuses are published in a separate volume.

N.B.—The divisions in Science and Art subjects other than Mathematics (Subject V.), formerly described as Elementary Stage and Advanced Stage, are now described as Stage 1 and Stage 2 respectively, and the divisions in Science subjects formerly known as Honours Part I., and Honours Part II., are now described as Stage 3 and Honours respectively.

55.—(*cont.*)

XII. Geology
XIII. Mineralogy.
XVIII. Principles of Mining.
XXIII. Physiography.

XIV. Human Physiology.
XV. General Biology.
XVI. Zoology.
XVII. Botany.
XXV. Hygiene.

XXIV. Agricultural Science and Rural Economy.

(*b.*) Art.

Freehand Drawing in Outline.
Model Drawing.
Drawing in Light and Shade from a Cast.
Drawing on the Blackboard.*
Geometrical Drawing (Art).
Perspective.
Memory Drawing of Plant Form.
Drawing of Common Objects from Memory.
Anatomy.
Drawing from the Antique.
Drawing the Antique from Memory.
Drawing from Life.
Painting from Still Life.
Painting Ornament.
Historic Ornament.
Principles of Ornament.
Design.
Architecture.
Architectural Design.
Modelling from the Antique.
Modelling the Head from Life.
Modelling from Life.
Modelling Design.

* For the special conditions affecting the Examination in Drawing on the Blackboard, *see* Section 57 (*d*).

Local Examinations.

56. These examinations are intended for—

(i.) registered students in any subject of Science, for their examination in that subject;

(ii.) registered students in Art, for their examination in Art;

(iii.) registered students in an organised course under Section 33, for their examination in any subject of such course;

(iv.) teachers;

in schools recognised as eligible to earn grants from the Board.

For the conditions on which the examinations may be attended by other (External) candidates, *see* Section 65.

The examinations in 1904 will be held on the dates specified in the Examination Time-tables given in Appendix C. (Evening Examinations) and Appendix D. (Day Examinations).

No candidate may be examined in the same subject at the evening examinations and at the day examinations in the same year.

Practical examinations in Science.

57.—(*a.*) Examinations in Practical Chemistry (Subjects X*p.* and XI*p.*), and in Practical Metallurgy (Subject XIX*p.*), are held only in laboratories equipped in accordance with the requirements appended to the Board's Syllabuses for these subjects.

Where the number of candidates for examination working at the same time exceeds the number for which the laboratory is approved, the candidates may be examined in divisions. Not more than two such divisions will be allowed, and the number of candidates in each division working at the same time must not exceed the number for which the laboratory is approved.

(*b.*) Practical examinations for candidates in Honours in certain subjects may be held at South Kensington, or at some other centre, in addition to a written examination (*see* syllabus of each subject). Such practical examinations will be held as early as possible in June or July.

Candidates who are instructed to attend these examinations at South Kensington or any other centre, receive a maintenance allowance of 7*s.* 6*d.* a night, while required to be absent from home, and third class railway fare; but no cab or omnibus fares are allowed.

57.—(*cont.*)

(*c.*) Special examinations may be held for Navigation Schools. Particulars of these examinations and of the capitation grants payable to such Schools (Form 491*a*) will be forwarded on application.

(*d.*) Examinations in drawing on the blackboard will be held by Inspectors during the months of April, May, and June, 1904, at approved centres.

Managers who desire the approval of any particular centre must apply to the Board not later than 30th November 1903, stating the probable number of candidates. No examination will be held at any centre unless at least 30 candidates have applied for examination.

A list of approved centres, showing in each case the name and address of the Secretary, will be issued to the Managers of Schools of Art and Art Classes during the month of January.

Managers must forward Form 278 to the Board, through the Secretary of an approved centre, on or before 1st March 1904.

58. The grades of success at the Examinations are "first class" and "second class." Grades of success.

Exceptions.—(1) In Section 1 of Stage 1 of Science Subjects XV. and XXIII. there is only one grade of success, viz.: "pass."

(2) In the Art subjects of Drawing and Modelling from the Life and Architectural Design there is a further grade of success, viz.: "excellent."

59. For the conduct of examinations the Board recognize Conduct of Examinations.

either (1) Special Local Secretaries and Assistants;

or (2) Special Paid Superintendents;

or (3) Managers.

60. Where numerous examinations have to be held, or where large schools or classes have to be examined, the Board may require the appointment of a Special Local Secretary to manage the whole business of the examinations. This Officer may receive payment as hereinafter provided. Special Local Secretary and Assistants.

The Special Local Secretary may be appointed by the Board on the nomination of a County or County Borough Council. Nomination and appointment of Special Local Secretary.

60.—(*cont.*)

Assistants for Special Local Secretary.

Assistants will be appointed by the Board to act as Superintendents at the examinations on the nomination of the Special Local Secretary.

The nomination of the Special Local Secretary must be sent to the Board not later than **15th February 1904.**

Candidates for the Examinations, their relatives, their teachers, or other persons who have a direct interest in the success of candidates for examination are ineligible to act as Special Local Secretaries or Assistants for the district in which such candidates are to be examined.

When a Special Local Secretary has been appointed, the Board will, as a rule, correspond with him alone on all subjects connected with the examinations. He must arrange for holding the examinations at convenient centres, subject to the approval of the Board, the number of these centres being as few as possible. As he is charged with the general supervision of the examinations, he may not act in the place of an assistant except either in the case of an emergency, or on an occasion on which there is an examination at but one centre.

The Special Local Secretary, after noting the application made to him on the Forms 119, must forward the forms, together with the fees of the candidates, to the Board not later than the 27th March for the evening examinations, and 5th May for the day examinations. The Special Local Secretary should refuse to provide accommodation for any candidate whose name has not been returned to him before he transmits the formal application for papers, etc., to the Board.

Local contribution toward the expenses of examination.

61. The Special Local Secretary may receive payment for the services of himself and his Assistants on the under-mentioned scale out of a fund to which, on the prescribed certificate (Form 983) being furnished, the Board will make a contribution equivalent to one-half the whole expense of the examination on the scale laid down; provided that the contribution so made does not exceed two shillings and sixpence for each paper or exercise worked at the examination, exclusive of papers or exercises in Stage 1.

The financial arrangements of the examinations are, subject to the regulations of the Board, entirely under the control of the body by which the Special Local Secretary is nominated, to which body he is required to submit his accounts. The Special Local Secretary shall account for the fees paid by external candidates for examination to the nominating body, who will use them in helping to provide the moiety required from the locality for examination expenses to meet the grant given by the Board. Each school having students for examination may be required by the Special Local Secretary to pay its contribution prior to the time of the examination; the students of any school from which such contribution has been so required, but has not been received, may be excluded from the

61.—(cont.)

examination. In levying this contribution the balance of fees available should be taken as part of the local moiety.

The Special Local Secretary is allowed a fee * of half a guinea for each period of three or four hours during which an examination is to be held. When, however, he acts in place of an assistant he will receive no additional fee. He is also allowed a fee * of half a guinea for every 75 papers worked at the examination.

For attendance throughout an examination which extends over a period of three or four hours, each assistant who is required to attend for that period is allowed a fee * of half a guinea. Where that period is materially exceeded, the Board may allow a double fee.*

Superintendents.

62. Where a County or County Borough Council accepts responsibility for holding examinations for which no Special Local Secretary is appointed, it may nominate Special Paid Superintendents to conduct them. Other Managers may nominate Superintendents of examinations in Still Life Painting or Casting. Such Superintendents will be paid at the rates allowed to Special Local Secretaries' Assistants, and will be subject to the regulations, as far as they apply, for such Assistants.

The nomination of Superintendents under this section must be sent to the Board not later than 15th March.

Examination Secretary.

63. Where no Special Local Secretary or Special Paid Superintendent is appointed, the conduct of the examination devolves upon the Managers of the school or class requiring examination, and the Board will recognise their Correspondent as Examination Secretary.

Where two or more schools or classes, within reasonable distance of one another, require simultaneous examination, the Board may call upon their Managers to appoint one of themselves as the Examination Secretary. He must make arrangements for the examination or examinations in question at a common centre.

No payment for the conduct of an examination is made by the Board to Managers or to an Examination Secretary under this Section.

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* These fees will not be paid by the Board in respect of Examinations in Stage 1. When an examination in Stage 1 is held concurrently with an examination in Stage 2, the same Superintendents may supervise both examinations provided the total number of candidates to which their supervision is restricted by the Regulations is not exceeded. The cost of additional Superintendents necessitated by the presence of Stage 1 Candidates must be defrayed wholly from local sources.

Application for Examination by Managers.

64. Managers must apply to the Board or, where such officer is appointed, to the Special Local Secretary, or to the Examination Secretary, as the case may be, for examination papers on Form 119, not later than the 20th March * for the Evening examinations and the 30th April * for the Day examinations.

The Board cannot undertake to entertain late or irregular applications.

Where papers in Stage 1 of any subject are applied for, the form of application must be accompanied in each case by the sum of 1*s.* 6*d.* for each such paper asked for therein. For papers in Stage 1 of Practical Chemistry or Practical Metallurgy the fee will be 2*s.* 6*d.* per paper. The number of papers requisitioned cannot be subsequently varied, and no part of the remittance is returnable.

Examination of External Students.

65. External Candidates (*see* Section 56) must make an application, accompanied by the prescribed fee, to the Special Local Secretary (where one has been appointed) or to the Correspondent of the body conducting the examinations, by the 18th March * for admission to the Evening examinations, and by the 28th April * for admission to the Day examinations.

Special Local Secretaries, or Managers who hold an examination, must admit to it External Candidates who have made due application to them to sit.

Exceptions.—(1) At the Day Examinations External Candidates can only be examined at centres where Examinations in the required subjects are to be held for other Candidates.

(2) The admission of an External Candidate to an examination in Practical Inorganic Chemistry, Practical Organic Chemistry, Practical Metallurgy, or Modelling and Casting is not obligatory.

An External Candidate may be charged a fee of 2*s.* 6*d.* for each morning, afternoon, or evening of examination for which his name is registered. Where such a candidate is admitted to a subject named in Exception 2 above, the fee may be 3*s.* 6*d.* The fee of 2*s.* 6*d.* or 3*s.* 6*d.* is in addition to any examination fee payable to the Board under Section 64.

Custody of Examination questions.

66. The examination papers will be forwarded to the Special Local Secretary, or to the Examination

* For admission to the examination in Blackboard drawing, application should be made to the Secretary of the Centre. As to the date before which application should be made, *see* Section 57 (*d*).

66.—(*cont.*)

Secretary, as the case may be, who will be responsible for their safe custody and distribution.

Where any special circumstances render it desirable another person may be appointed to receive, take charge of, and distribute, the papers.

The packets of examination questions must not under any circumstances be permitted to pass into the hands of a teacher, of a candidate for examination, or of any other person interested in the success of the examination.

Regulations for Examination.

67. The detailed regulations (Form 91) for the conduct of the examinations are issued in due course to Managers and Special Local Secretaries who have applied for examinations in accordance with the rules.

Irregularities at examination.

68. The Board may disallow examinations where there has been a breach of the Regulations, or where there is evidence of fraud. They will investigate cases of suspected irregularity, and may require any or all of the candidates to be re-examined. If any candidate should fail to appear at such investigation, or decline to be re-examined, all his previous examinations may be cancelled. When a re-examination is necessary owing to the failure of an examination through no fault of the candidates, the cost of such re-examination may be charged to the Special Local Secretary, or to the Managers. A re-examination will not be accepted for the purposes of the Scholarships, &c., mentioned in Part III. of these Regulations.

Board not responsible for mistakes.

69. All possible care is taken to forward the examination papers in accordance with the applications, and to issue the results correctly, but the Board cannot undertake to rectify mistakes, nor will they be responsible for any incidental loss.

EXAMINATION OF STUDENTS' WORKS.

Examination of students' works.

70. Art Works eligible for examination at South Kensington must have been executed by students, under the instruction of Art teachers holding the Art Class Teacher's Certificate, or the Art Master's Certificate, or special qualifications recognised by the Board, wholly in the class rooms at the meetings of the class during the school-year.

70.—(*cont.*)

Work in various materials from students' designs, such as earthenware, porcelain, glass, metal, wood, paper, leather, textiles, &c., may be submitted for the National Competition, to fully illustrate or explain the original drawn, painted, or modelled designs forwarded for examination.

Works in Science subjects II., III., and IV., similarly executed by students in science classes for those subjects, are eligible for examination at South Kensington.

A work which has been once submitted may not be again submitted.

Exhibition of National Competition works.

The best of these works will be selected to enter into a National Competition, which is held annually. Works gaining medals and prizes (*see* Section 75) at this Competition will be exhibited in London and in other towns where suitable space can be provided.

Applications from Managers for the loan of these works must be made not later than 1st July.

Works for Certificates.

71. Works submitted for Art Masters' and Art Class Teachers' certificates by registered Art students must be forwarded with the school work of the year by the 1st April.

Works submitted for Certificates by Candidates other than the above must be sent (carriage prepaid) direct to the Board of Education, South Kensington, London, S.W., by the 1st April. Each such candidate must fill up a supplementary fly-leaf to Form 528 in respect of the works submitted.

Regulations for submission of works.

72. The detailed regulations relative to the submission of works (Form 564) will be forwarded on application.

PART III.

REWARDS TO STUDENTS AND OTHERS.

CHAPTER I.

Certificates, Prizes, and Medals.

Examination Certificate.

73. A certificate will be issued for each candidate who obtains a success at an examination in any subject.

In Honours in Chemistry or Metallurgy the complete Certificate will not be issued until the candidate has been successful in both Theoretical and Practical Examinations. These successes need not necessarily be taken in the same year.

Attendance Certificate.

Certificates of attendance will be supplied to Managers of Schools who furnish a list on Form 279 of the names of students who have attended during the School-year at least 25 hours' instruction in Stage 1 of a subject under Divisions II. or IV. of Section 32 of these Regulations for issue to such students.

All the attendances which are to qualify a student for a certificate must have been made under one body of Managers and in a single school-year.

City Guilds Certificate.

The Full Certificates granted by the City and Guilds of London Institute, which are issued to those students who pass the Institute's Examination in Technology (Honours Grade) and have qualified in Science and Art Subjects, will, on the application of the Institute to the Board, be stamped by the Board.

Group Certificate.

On the application of the managers a Group Certificate will be issued to a student who for three consecutive years has followed a continuous course of instruction. The whole course of instruction, except in the case of the more advanced work, which may be taken at a place of higher instruction, must as a rule be taken in one recognised school.

In Science the course must include practical work in at least one subject in which the student undergoes an examination in theory, and he must obtain a success in Stage 2 or 3 or in Honours of three of the subjects named as competitive of one of the Groups (A., B., C., D., E.) in which subjects are arranged for the National Scholarship Competition. (*See* Section 82.)

In Art the course must provide for such instruction of a student in Drawing, Painting, Modelling, and the History and Principles of Art

73.—(*cont.*)

as leads definitely to some Architectural, Ornamental, or Decorative purpose; and the student must obtain a first class success in at least four of the subjects named as competitive of one of the Groups (A., B., C., D.) in which subjects are arranged for the National Scholarship Competition. (*See* Section 82.)

74. A small number of King's prizes of books, instruments, &c., are given to those who do best at the local examinations in Art or in Stage 2 or 3 of a Science subject, or in the second or any higher stage of Mathematics; provided that they are eligible to receive them and have made the qualifying number of registered attendances in that subject during the school year in a school under the Board.

The detailed conditions for the award of these prizes (Forms 161 and 161*a*) will be forwarded on application.

dals, &c.

75. Bronze Medals are given to all candidates who obtain a first class in Honours in a Science subject.

A candidate in Honours in Chemistry or Metallurgy must obtain a first class in both theory and practice before he is eligible to receive a medal.

Medals and books are awarded for the best of the works selected for the National Competition (Section 70). About 12 gold, 60 silver, and 200 bronze medals are thus awarded.

The detailed conditions for the award of these prizes (Form 161*a*) will be forwarded on application.

CHAPTER 2.

Local Science and Art Exhibitions.

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76. Grants to aid the foundation of Local Science and Art Exhibitions are made on the condition that they are awarded on the results of a competition, or on such other conditions as may be specially approved by the Board, and that a sufficient sum is provided for the purpose of the Exhibition by the contributions of living persons.

Contributions from a rate levied under the Technical Instruction Act, 1889, or under Part II. of the Education Act, 1902, will be held as satisfying the last-named condition.

76.—(*cont.*)

Contributions from the residue of the moneys vested in Local Authorities under the Customs and Excise Act, 1890; funds derived from endowments or from moneys held in trust, the donor being dead; subscriptions not raised for this definite purpose; and other mere surplus funds, will not be so held.

The Board may refuse to aid any Exhibition for which there is not a sufficient number of competitors, or to appoint a candidate whose financial circumstances do not appear to warrant such aid.

77. A grant of 25*l.* per annum towards a local Science and Art Exhibition is made to the Managers of the local fund who lodge with the Board before the 5th April the like sum for the maintenance of a student at some college or school where a thorough course of Science or of Art instruction of an advanced character may be obtained. The exhibitioner's whole time must be devoted to such instruction. The Exhibition may last for one, two, or three years. Tenure of Local Science and Art Exhibitions.

a. The Exhibition must be awarded in competition at the Board's annual examinations in Science or Art. The competition may be held at either the day or evening series of examinations, but not at both. The Managers may select the subjects of Science or branches of Art for the competition, and they may fix any relative amount of marks they consider best to assign to them.

b. The place or places where the Exhibition is to be tenable and where the student is to pursue his studies may be fixed by the Managers, subject to the approval of the Board, provided that the Exhibitioner shall always have the option of going to the Royal College of Science—or the Royal College of Art—South Kensington, at which the fees for instruction will be remitted. If the Exhibitioner is to pursue his studies at the Institution applying for the Exhibition, the fees for instruction must be remitted.

c. The grant of the Board will be paid from year to year on condition that a like payment has been made by the Managers, and that the student has pursued his studies satisfactorily according to regulations fixed by the Board.

d. The Board will pay 10*l.* of the local contribution to the Exhibitioner upon receipt of notification (on Form 1066A) that he is commencing his studies. For the next three months of a term, a further monthly payment of 5*l.* will be made out of the local contribution. 5*l.* per month for three more months will be paid from the Board's grant when a certificate (Form 851) has been furnished by the Principal of the Institution at which the Exhibition is held, stating that the Exhibitioner is making satisfactory progress. The payment of the balance (10*l.*) of the Board's grant will be made when the session terminates, and when a satisfactory report (Form 851) of the Exhibitioner's progress in his studies has been received from the Principal.

e. If the Exhibition is held at the Royal College of Science—or the Royal College of Art—South Kensington, 5*l.* will be paid to the Exhibitioner monthly during the session by the Board.

77.—(*cont.*)

f. Application for the Exhibition must be made (on Form 286) before the 5th April. The Board must be informed before the following 1st September (on Form 287) where the Exhibitioner will pursue his studies.

g. Application for the renewal of the Exhibition for a second or third year must be made on Form 472 as soon as the Board's grant for the preceding year has been paid, and not later than the 1st September.

CHAPTER 3.

Free Studentships, Local Scholarships, and Princess of Wales' Scholarships.

Free Studentships.

78. A Free Studentship tenable at a School of Art is granted to any student of such school who, being a draughtsman, designer, modeller, or handicraftsman, (1) has gained a first class in the immediately preceding Art Examinations in Stage 2, or a first class in subjects not divided into stages, and whose works are passed as satisfactory at the preceding annual examination, (2) has attended the School of Art for two consecutive years, (3) is prepared to attend regularly for the year following the date of his appointment, and (4) is recommended by the Managers of the School, who undertake to admit him to the School without payment of fees for that year.

The Board may exceptionally award free studentships to other deserving students recommended by Managers.

Local Scholarships.

79. Seventy-two Local Scholarships in Art—twenty-four open each year—are awarded by the Board, and are tenable at Schools of Art.

A Local Scholarship is awarded on the results of the Evening Examinations of the current year and previous successes are not counted. It is held on the condition that the holder attends the prescribed course of instruction regularly, complies with all the rules, and passes the prescribed examinations. The subjects which may be taken, and the scale of marks, are identical with those

79.—(*cont.*)

prescribed for the competitions for Royal Exhibitions tenable at the Royal College of Art (*see* the Prospectus of the College, which is published in a separate volume).

A Local Scholarship is tenable for three years, with an allowance of £20 a year, at any School of Art under the Board, which is open at least three days and five nights a week, and which will remit the fees for instruction of the holder. The Scholar must attend a School of Art during at least 40 weeks in the year for 30 hours each week, of which 18 hours at least must be in the day. The Scholarship commences on the date at which the school where the Scholarship is tenable reopens after the summer vacation in each year. The allowance is paid quarterly, on the receipt of a certificate from the Master and Correspondent of the School of Art that the scholar has attended regularly and pursued his studies satisfactorily.

A candidate who has held a Local Scholarship is ineligible to compete for it again.

Princess of Wales' Scholarships.

80. Two Princess of Wales' Scholarships, of about the value of 25*l.* and 11*l.* respectively, are open to competition each year and are awarded to the two women students of the Schools of Art who take the highest prizes of the year in the National Competition. These Scholarships, which are intended to enable students to continue their regular course of instruction in a School of Art, date from the 1st October in each year, and are tenable for one year in the School of Art only where they have been gained. The Scholarships are not awarded to the same persons for more than three years in succession.

Each "Princess of Wales' Scholar" is required to present half-yearly reports of the course of study she has pursued at her School of Art during her tenure of the scholarship and of her attendances. These reports must be sent through the Correspondent of the School of Art in which the Scholar is studying, on the 31st of March and 30th of September. A moiety of the sum awarded will be paid on the receipt of each report if it be satisfactory.

CHAPTER 4.

Other Grants and Rewards.

Grants and Privileges to Teachers and others.

81. The following grants and privileges are allowed to teachers and others:—

a. Short courses of instruction in Science or Art for a limited number of Science Teachers, Art Teachers, and Advanced Art Students are given in the Royal Colleges of Science and Art during July or August.

Only those are eligible for admission to a course who are recognised as qualified to teach the subject or subjects of the course.

The selected candidates will receive third class railway fare for one journey to and fro between their homes and the college, and 3*l.* towards their expenses while attending the courses. In the case of teachers or students resident in London or its vicinity a reduction is made in the grant.

Information as to the precise period of these courses is circulated to Schools about April, and forms of application for admission are sent to Secretaries of Boards of Managers for circulation to the teachers.

b. Science Teachers who are sent abroad, or who travel in the service of the Board, receive 10*s.* a night while required to be absent from home, second class railway fare, and cab or omnibus fares.

c. Aid is granted to a limited number of teachers engaged in science teaching who are selected to attend instruction at Provincial Science Colleges. Particulars of the courses of instruction and of the nature and conditions of the Board's assistance will be sent on application.

d. Grants will be made to enable a limited number of masters and students of Schools of Art and Art Classes to see the works in the National Competition exhibited at South Kensington; to visit and study in the Victoria and Albert Museum, the Royal College of Art, and other Institutions, and, in special cases, Foreign Towns, Schools, and Galleries; to study and make sketches of buildings and of objects in museums; or to study in any approved centre of Art instruction. They may be required to do special work for the Board.

Application must be made on Form 1178 not later than 30th June.

Teachers and Students may be allowed third class railway fare and not more than 7*s.* 6*d.* a night while required to be absent from home. Cab or omnibus fares are allowed only when journeys are made in the service of the Board; and then second class railway fares and 10*s.* personal allowance per night while required to be absent from home may be charged.

e. Any approved Teacher who is actually engaged in teaching or who has recently taught Science or Art classes recognised by the Board, may be permitted to attend, without the payment of any fee, any course of lectures at the Royal Colleges of Science or Art, London, as far as circumstances may allow. Application for this privilege should be made to the Registrars of these Colleges.

81.—(*cont.*)

Facilities will be given to teachers of Science and Art Schools and Classes recognised by the Board, who bring their students to the Victoria and Albert Museum, to examine the collections. When a teacher desires to avail himself of this privilege the Secretary of his school should write to the Board at least one week prior to the intended visit, stating the number of students by whom the teacher will be accompanied, the proposed date and hour of the visit, and the collection which it is desired to inspect. The visits may take place on Mondays, Tuesdays, and Saturdays from 10 a.m. to 9 p.m., and on Wednesdays, Thursdays, and Fridays from 10 a.m. to 4, 5, or 6 p.m., according to the time of the year. Such visits are not allowed on a Bank Holiday. Class-rooms are available for the use of teachers giving science demonstrations to their students, except in the Southern Galleries, where the Engineering and Naval Architecture Collections are arranged.

Royal Exhibitions, &c

82. Royal Exhibitions, National Scholarships, Free Studentships, and Studentships in Training, tenable for the most part at the Royal College of Science or the Royal College of Art, are awarded by the Board on the results of the Evening Examinations (Section 56). For the conditions of award, *see* the Board's Regulations relating to Museums and Institutions.

Whitworth Scholarships and Exhibitions.

83. The Whitworth Scholarships and Exhibitions are awarded in competition at the Evening Examinations on the conditions stated in the Whitworth Prospectus, which is published separately.

APPENDIX A.

REGISTRATION.

General Conditions.

The conditions as to registration are as follows :—

(1.) No student may be registered for the purposes of a grant under these Regulations (1) who is under 12 years of age, or (2) in respect of whom any grant is paid by the Board of Education under any other Regulations.

For the year ending the 31st July, 1904, the last-mentioned restriction will not apply in the case of any student on account of whom a grant is paid under the Board's Regulations for the instruction and training of pupil-teachers (Section 4).

(2.) Managers are responsible for the accuracy of all registration. They may, with the sanction of the Board, adopt any system for this purpose which they may consider convenient, and sufficient to enable them to certify to the correctness of the attendances on which a claim for payment is based, provided that the system does not lend itself to abuse, and has the recommendation of the Inspector. The absence of a register will be a bar to the payment of a claim.

(3.) The Board may require any register to be forwarded to them. Registers so forwarded will, as a rule, be subsequently returned to the Managers, but Managers before parting with a register should extract any information of which they may have immediate need.

Entrance Register.

(4.) Managers are required to keep an entrance register, which must show for each student the full name, age (years and months), occupation, address, and date of joining the School. A record of the fees paid by each student must also be kept in such a form as may be approved by the Inspector.

Attendance Register.

(5.) A model form of register for recording attendances of students will be sent on application to the Board, but the Managers must themselves provide the necessary registers for actual use.

The name of the School, the subject or course of instruction, the name of the teacher, the day, hour, and duration of the lesson must appear on the face of each attendance register. There should also be a space on which the Managers may, by their dated signatures, record the visits paid by them to the classes, and the number of students then actually present.

(6.) The registration of the attendances made in each year must be kept distinct.

(7.)—(*a.*) No lesson may be registered which is less than one complete half-hour in duration in Division I. of Section 32 of these Regulations; of less than one hour in Divisions II., III., and V.; and of less than forty minutes for a lesson in theory, and ninety minutes for a lesson in practical work in Division IV.

(*b.*) An attendance of not less than forty minutes may include five minutes for registration or other necessary preliminaries, but, subject to this allowance, the grant may only be claimed in respect of the time during which the actual work of the lesson is proceeding.

(*c.*) The attendance of a student must be registered before the instruction commences, unless a special system of registration has been sanctioned, or unless the mode of registration stated in the exception in condition 9 is adopted.

(8.) Except in the case of organised courses recognised under Section 33 or Chapter 3 of Part I. of these Regulations, the attendance in each subject or course, and in each stage or section of such subject or course, must be entered in a separate register. In Schools of Art and in other classes under Division II., the separate registration of each subject is only necessary when a claim for payment on the results of examination in such subject is to be made.

(9.) The presence of each student at a lesson must be definitely marked in the column devoted to that lesson by a stroke /, and his absence by a circle O. Immediately the attendance has been marked for any meeting the total number of students present at that meeting must be entered at the foot of the proper column in the register. The registration of students who leave before the completion of a lesson must be cancelled by drawing a circle round the attendance mark /, thus Ø.

Exception.—In Schools of Art under Section 51 (*b.*) of these Regulations, and in classes under Division II. of Section 32, the attendance of Students must be recorded by entering against the names, in the columns devoted to the meeting of the class, the time in hours and half-hours that each student was actually present under instruction. With the special sanction of the Inspector the attendances of Students may be similarly recorded in classes for Practical Work, in Mathematics, and in Subjects II., III., and IV., under Division IV.

(10.) At the end of each course the following totals must be entered—the number of hours attended by each student, the total number of students who make the minimum number of attendances, and the total number of hours made by all these students.

(11.) All the entries must be made in ink. Blanks and erasures are not permitted. If any error in the registration is made, it should be corrected by striking through the original entry, so that both the original and the corrected entry appear in the register.

(12.) Visits of students to Galleries, Museums, or other institutions, or places connected with their work, or their attendance for field work, may be recorded in the attendance register, and counted as attendances for grants, if the students are accompanied by the recognised teacher of the class, and all the arrangements are previously submitted to, and approved by the Inspector. At least a week's notice of the intended visit must be given.

APPENDIX B.

QUALIFICATIONS OF TEACHERS.

1. Section 18 provides that the teachers must possess such qualifications as may be required by the Board.

The qualifications named in this Appendix indicate that the teacher is regarded by the Board as *primâ facie* qualified to give instruction in any subject to which they refer. The possession by a teacher of any particular qualification is not, however, at present made a condition of the award of grant to the class under his instruction, nor, on the other hand, can it necessarily be accepted as conclusive evidence that he is qualified to give instruction of the character and standard required by the particular circumstances of the class.

2. Teachers placed on Column B of the Official Register of Teachers will be accepted by the Board as qualified to teach the subjects covered by the degree, or other test of attainments which was required for their entry on such column.

Teachers placed on any Supplemental Register for any subject annexed to the Register of Teachers, will be accepted by the Board as qualified to teach that subject.

A first class in Stage 2, a pass in Stage 3, or a success in Honours at the Board's Examination in any subject of Science, is recognised as a qualification to teach that subject.

Certain special qualifications (*see* Form 1033) are recognised as applicable to certain Science Subjects.

3. The qualifications usually recognised by the Board to cover instruction in Art are of three grades, viz. :—

(i.) The Elementary Drawing Certificate.

This qualification is recognised by the Board to cover instruction in Elementary Drawing under Division I. of Section 32 of these Regulations.

(ii.) The Art Class Teacher's Certificate.

This qualification is recognised to cover Art instruction under Division II. of the same section.

(iii.) The Art Master's Certificate.

This qualification is required for the Head Mastership of a School of Art under Section 43 of these Regulations.

These Certificates are issued to candidates who fulfil the conditions and apply to the Board for them.

The detailed conditions for the award of these Certificates (Form 1032) will be forwarded on application.

4. The higher grant will not be given for any subject marked with an asterisk under Division I. of Section 32 of these Regulations unless the Board are satisfied in each case that the teacher is specially competent to teach the subject.

The following Certificates issued by the City and Guilds of London Institute, viz., the Teachers' Certificate in Manual Training, the Evening School Teachers' Certificate and Teacher's Diploma in certain subjects of Domestic Economy, and also the First Class Full Certificate in any Technological subject, will be recognised as affording evidence of competence to teach the subject or subjects covered by the Certificates.

5. Persons recognised by the Board, under previous Regulations, as qualified to teach a subject will continue to be so recognised.

APPENDIX C.

Form 90.

TIME TABLE* OF EVENING SCIENCE AND ART EXAMINATIONS IN APRIL, MAY, AND JUNE, 1904.

1904.		ART.
30th April, Saturday	6 to 7.30 p.m. 8 to 10 p.m.	GEOMETRICAL DRAWING. PERSPECTIVE.
2nd May, Monday	7 to 10 p.m.	PRINCIPLES OF ORNAMENT.
3rd „ Tuesday	10 a.m. to 4 p.m. (See *Note.*) 7 to 9 p.m.	PAINTING FROM STILL LIFE. DRAWING THE ANTIQUE FROM MEMORY.
4th „ Wednesday	7 to 9.30 p.m. 7 to 9 p.m.	FREEHAND DRAWING in Outline. DRAWING OF COMMON OBJECTS FROM MEMORY.
5th „ Thursday	7 to 10 p.m.	DRAWING IN LIGHT AND SHADE from a Cast.
6th „ Friday	7 to 9.30 p.m.	MODEL DRAWING.
7th „ Saturday	5 hours (between 10 a.m. & 10 p.m.)	DRAWING FROM LIFE, including one hour for Drawing from Memory, and an interval of one hour between the time for collecting the drawings made from the Model, and the time for the commencement of the Drawing from Memory. (*The five hours must be consecutive and the same for all Candidates attending at the same centre.*)
9th „ Monday	6 to 10 p.m.	DRAWING FROM THE ANTIQUE.
10th „ Tuesday	7 to 10 p.m.	ANATOMY.
11th „ Wednesday	6 to 10 p.m.	DESIGN, Stage 1, Stage 2, and Honours.
12th „ Thursday	7 to 10 p.m.	HISTORIC ORNAMENT.
13th „ Friday	6 to 10 p.m.	PAINTING ORNAMENT.
14th „ Saturday	6 to 10 p.m.	ARCHITECTURE.
16th „ Monday	7 to 9 p.m.	MEMORY DRAWING OF PLANT FORM.

* The examinations in Drawing on the Blackboard are held during April, May, and June. Application for admission to the examinations in this subject must be made to the Secretary of an approved centre not later than 1st March (for the special conditions affecting these examinations *see* Section 57 (*d*) of the Regulations).

1904.			Art.
17th May, and 18th	Tuesday and Wednesday	6 to 10 p.m. 8 hours (between 10 a.m. & 10 p.m.) (See *Note.*)	Modelling the Head from Life. For Candidates to Cast their Clay Models. (*The eight hours must be consecutive and the same for all Candidates attending at the same centre.*)
16th to 19th and	„ Monday to „ Thursday and	6.30 to 10 p.m. (Each evening.)	Modelling from the Antique.
20th	„ Friday	8 hours (between 10 a.m. & 10 p.m.) (See *Note.*)	For Candidates to Cast their Clay Models. (*The eight hours must be consecutive and the same for all Candidates attending at the same centre.*)
30th to 1st June,	„ Monday to Wednesday	4 to 10 p.m. (See *Note.*)	Architectural Design.
2nd and 3rd and	„ Thursday and „ Friday and	6.30 to 10 p.m. (Each evening.)	Modelling Design (Stage 2 only).
4th	„ Saturday	8 hours (between 10 a.m. & 10 p.m.) (See *Note.*)	For Candidates to Cast their Clay Models. (*The eight hours must be consecutive and the same for all Candidates attending at the same centre.*)
6th to 10th and	„ Monday to „ Friday and	6.30 to 10 p.m. (Each evening)	Modelling from Life.
11th	„ Saturday	8 hours (between 10 a.m. & 10 p.m.) (See *Note.*)	For Candidates to Cast their Clay Models. (*The eight hours must be consecutive and the same for all Candidates attending at the same centre.*)
13th to 16th and	„ Monday to „ Thursday and	6.30 to 10 p.m. (Each evening.)	Modelling Design (Honours).
17th	„ Friday	8 hours (between 10 a.m. & 10 p.m.) (See *Note.*)	For Candidates to Cast their Clay Models. (*The eight hours must be consecutive and the same for all Candidates attending at the same centre.*)

Note—On the 3rd, 30th, and 31st May and 1st June the six hours include half an hour for refreshment. On the 3rd May the half hour

must be taken by all Candidates from 1 to 1.30 p.m. On the other dates the half hour each evening must be taken by all Candidates from 7 to 7.30 p.m. The eight hours, including half an hour for refreshment, for casting on the 18th and 20th May, and 4th, 11th, and 17th June, may be taken as convenient in the morning and afternoon, or the afternoon and evening of each day.

1904.	p.m.	SCIENCE.
30th April, Saturday	6 to 10	I.—Practical Plane and Solid Geometry.
	7 to 10	XXIV.—Agricultural Science and Rural Economy (Division I.), Stage 1 and Stage 2.
2nd May, Monday	7 to 10	VI*a*.—Theoretical Mechanics.—Solids, Stage 1 and Stage 2 only.
3rd „ Tuesday	7 to 10	VII.—Applied Mechanics. XIV.—Human Physiology.
4th „ Wednesday	7 to 10	XVIII.—Principles of Mining. XXIV.—Agricultural Science and Rural Economy, Stage 2 (Division II.) and Honours. The examination in Stage 1 (Division II.) will be the same as that in the Alternative Stage 1 of Theoretical Inorganic Chemistry, and will be held, as shown below, on 16th May from 7 to 10 p.m.
5th „ Thursday	7 to 10	VI*b*.—Theoretical Mechanics. Fluids, including Stage 3 and Honours in Solids and Fluids. XX.—Navigation and Stage 3 and Honours in Navigation and Spherical and Nautical Astronomy. XII.—Geology.
6th „ Friday	7 to 10	VIII*c*.—Heat, Stage 2, Stage 3, and Honours. XVI.—Zoology.
7th „ Saturday	6 to 10	III.—Building Construction.
9th „ Monday	7 to 10	XXIII.—Physiography. XIX.—Theoretical Metallurgy, including the written examination in Honours of Metallurgy.
10th „ Tuesday	7 to 10.30	V.—Mathematics, Stages 1, 2, 3, 4, and Honours in Division I.
11th „ Wednesday	7 to 10	VIII*b*.—Light, Stage 2, Stage 3, and Honours. XV.—General Biology.
12th „ Thursday	7 to 10	IX.—Magnetism and Electricity.

1904.		p.m.	Science.
13th May, Friday		7 to 10	VIII.—Sound, Light, and Heat, Stage 1. VIII*a*.—Sound, Stage 2, Stage 3, and Honours.
14th „	Saturday	6 to 10	II.—Machine Construction and Drawing. IV.—Naval Architecture.
16th „	Monday	7 to 10	X.—Theoretical Inorganic Chemistry, including alternative Elementary Chemistry and Honours of Chemistry, Organic and Inorganic.
17th „	Tuesday	7 to 10	XI.—Theoretical Organic Chemistry. XXII.—Steam.
18th „	Wednesday	7 to 10	V.—Mathematics, Stages 5, 6, 7, and Honours in Division II. XXV.—Hygiene.
19th „	Thursday	2.30 to 10.30	XI*p*.—Practical Organic Chemistry. Stage 1 - Written, 6 to 7 p.m. Practical, 7.15 to 9.30 p.m. Stage 2 - Written, 6 to 7 p.m. Practical, 7.15 to 10.30 p.m. Stage 3 - 2.30 to 10.30 p.m.
20th „	Friday	7 to 10	XVII.—Botany. V*p*.—Practical Mathematics, Stage 1, Stage 2, and Stage 3.
30th „	Monday	7.15 to 9.30	X*p*.—Practical Inorganic Chemistry, Stage 1.
31st „	Tuesday	2 to 10	XIX*p*.—Practical Metallurgy. Stage 1, 6 to 10 p.m. Stage 2, 5 to 10 p.m. Stage 3, 2 to 10 p.m.
1st June, Wednesday		6 to 9	XIII.—Mineralogy. XXI.—Spherical and Nautical Astronomy, Stage 1 and Stage 2.
4th „	Saturday	2.30 to 10.30	X*p*.—Practical Inorganic Chemistry, Stage 2 and Stage 3. Stage 2 - Written, 5.15 to 6.15 p.m. Practical, 6.30 to 10.30 p.m. Stage 3 - 2.30 to 10.30 p.m.

In laboratories where the Board has sanctioned the practical examination in two divisions, the times for the first division will be as follows:—Inorganic Chemistry, Stage 1, 3.30 to 5.45 p.m.; Stage 2,

1 to 5 p.m. Organic Chemistry, Stage 1, 3.30 to 5.45 p.m.; Stage 2, 2.30 to 5.45 p.m. The practical examination for the second division in the respective stages, and in the case of Stage 2 of X*p*. and Stages 1 and 2 of XI*p*., the written examination for both divisions will be held at the times stated in the time table above.

In Practical Metallurgy there will be, for all stages, a practical examination only. Where the Board has sanctioned the examination in Stage 2, or Stage 1 in two divisions, the examination of the first division will be held from 10 a.m. to 3 p.m. for Stage 2, and from 1 to 5 p.m. for Stage 1. The examination for the second division will be held at the times stated in the time table above.

In Science subjects in which Honours includes both a written and a practical examination, the examination papers to be set on above dates will include the questions for the written examination only. The dates of the practical examinations at South Kensington will be communicated to qualified Candidates in due course afterwards. The examination in Honours of Practical Chemistry will be held about June at appointed centres, and will extend over three or more days. The precise dates and places of examination will be subsequently announced.

APPENDIX D.

Form 90*d*.

TIME TABLE OF DAY SCIENCE AND ART EXAMINATIONS, JUNE, 1904.

These Examinations are confined to the Subjects and Stages specified. They do not include Papers in Stage 3 or Honours, and marks gained in them do not count in the Competition for Royal Exhibitions, National Scholarships, or Free Studentships; or for Whitworth Scholarships and Exhibitions; or for Royal Exhibitions and Local Scholarships (Art).

1904.

Monday, 13th June.	10 a.m. to 1 p.m.	Art	-	Drawing in Light and Shade from a Cast.
	2 to 5 p.m.	Science.	Subject. XXIV.	Agricultural Science and Rural Economy. Division I., Stage 1 and Stage 2.
Tuesday, 14th June.	10 a.m. to 12.30 p.m.	Art	-	Model Drawing.
	2 to 4.30 p.m.	„	-	Freehand Drawing in Outline.
Wednesday 15th June.	10 to 11.30 a.m.	„	-	Geometrical Drawing.
	12 to 2 p.m.	„	-	Perspective.
	10 a.m. to 2 p.m.	Science.	Subject I.	- Practical Plane and Solid Geometry, Stage 1 and Stage 2.
	3 to 6 p.m.	„	„ XXIV.	Agricultural Science and Rural Economy. Division II., Stage 2. The Examination in Stage 1 (Division II.) will be the same as that in the Alternative Elementary Stage of Theoretical Inorganic Chemistry, and will be held, as shown below, on 20th June, from 10 a.m. to 1 p.m.
Thursday, 16th June.	10 a.m. to 1 p.m.	„	„ VIII.	Sound, Light, and Heat, Stage 1.
			„ VIII*a*.	Sound, Stage 2.
	2 to 5 p.m.	„	„ VI*a*.	Theoretical Mechanics (Solids), Stage 1 and Stage 2.
Friday, 17th June.	10 a.m. to 1 p.m.	„	„ VIII*c*.	Heat, Stage 2.
	2 to 5 p.m.	„	„ IX.	Magnetism and Electricity, Stage 1 and Stage 2.
Saturday, 18th June.	10 a.m. to 1 p.m.	„	„ VI*b*.	Theoretical Mechanics (Fluids), Stage 1 and Stage 2.
	2 to 5 p.m.	„	„ VIII*b*.	Light, Stage 2.

1904.

Monday, 20th June.	10 a.m. to 1 p.m.	Science.	Subject X.	Theoretical Inorganic Chemistry, Stage 1, Alternative Stage 1, and Stage 2.
	2 to 5 p.m.	„	„ XIV.	Human Physiology, Stage 1 and Stage 2.
Tuesday, 21st June.	10.30 a.m. to 12.45 p.m.	„	„ X*p*.	Practical Inorganic Chemistry, Stage 1.
	3 to 6 p.m.	„	„ XII.	Geology, Stage 1 and Stage 2.
			„ V.	Mathematics, Stages 5, 6, and 7.
Wednesday 22nd June.	10 a.m. to 1 p.m.	„	„ V.	Mathematics, Stages 1, 2, 3, and 4.
	2 to 5 p.m.	„	„ XXV.	Hygiene, Stage 1 and Stage 2.
Thursday, 23rd June.	10 a.m. to 1 p.m.	„	„ XVII.	Botany, Stage 1 and Stage 2.
	2 to 5 p.m.	„	„ XXIII.	Physiography, Stage 1 and Stage 2.
Friday, 24th June.	9.15 a.m. to 2.30 p.m.	„	„ X*p*.	Practical Inorganic Chemistry, Stage 2. (Practical 9.15 a.m. to 1.15 p.m.; Written, 1.30 to 2.30 p.m.)
	3 to 6 p.m.	„	„ XV.	General Biology, Stage 1 and Stage 2.

The examinations in Drawing on the Blackboard are held during April, May, and June. Application for admission to the examinations in this subject must be made to the Secretary of an approved centre not later than 1st March (for the special conditions affecting these examinations see Section 57 (*d*) of the Regulations).

In laboratories where the Board have sanctioned the practical examination in two divisions, the second division in Stage 2 will be examined from 2.45 to 6.45 p.m., and in Stage 1 from 2.15 to 4.30 p.m. The practical examination for the first division, in the respective stages, and in the case of Stage 2 the written examination for both divisions, will be held at the times stated in the time table above.

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5. Woodwork—carved and inlaid.
6. Furniture and Types of Decorated Rooms.
7. Metalwork—iron, bronze, brass, lead, pewter, &c.

8. Goldsmiths' and Silversmiths' Work—for ecclesiastical and secular use.
9. Clocks and Watches.
10. Decorative Arms and Armour.
11. Jewellery.
12. Enamels on Metal—comprising cloisonné, champlevé, basse taille, and painted examples.
13. Mosaic-work in Stone and Glass.
14. Earthenware and Porcelain.
15. Glass Vessels.
16. Painted and Stained Glass Windows.
17. Ornamental Leatherwork.
18. Ornamental Bookbindings.
19. Ornamental Textile Fabrics—woven and printed.
20. Carpets.
21. Tapestry Hangings.
22. Embroideries.
23. Ecclesiastical Vestments.
24. Costumes—chiefly British.
25. Lace—Pillow and Needlepoint.
26. Decorative Musical Instruments.
27. Paintings.
    (*a.*) Paintings in Oil—chiefly of the British School.
    (*b.*) Paintings in Water-colour—historical collection of the British School.
    (*c.*) Miniatures—chiefly of the British School.
    (*d.*) Fresco and other Mural Paintings.

The Science Library contains Works on Science and the Reports, Journals and Transactions of Scientific Institutions and Learned Societies.

The Art Library contains Books, Drawings, Prints and Photographs relating to various branches of the Ornamental and the Fine Arts, also English and Foreign Periodicals relating to Art.

The Dyce and Forster Libraries illustrate the History of Literature and the Drama.

II.

1. Gifts illustrative of Science or Art are placed in the Victoria and Albert Museum, South Kensington, or the Branch Museum at Bethnal Green, on the understanding that they can be lent for short periods to Local Schools and Museums, unless express conditions are attached to their acceptance.

2. Objects are received on loan for exhibition with the approval of the Board of Education for a period of not less than six months and not exceeding a year. At the expiration of the time, the loan must be removed unless the Board have agreed to exhibit it for a further period. Objects received on loan may be exhibited at either of the above Museums, unless special agreement be made limiting them for exhibition at one or the other.

3. All possible care is taken of objects lent for exhibition, or submitted for purchase, but the Board cannot be responsible for loss or damage.

4. The cost of carriage to and from the Museum of objects accepted on loan is paid by the Board.

5. Photographs, copies, or casts of loans that may be useful for instruction in Science and Art Schools may be taken, unless the lender objects in writing. Two copies of any photograph of objects in a loan are sent to the lender. Permission to copy or photograph objects on loan is not granted to private persons without the sanction in writing of the lender.

6. No object can be received for purchase unless the price be named before or on delivery.

7. For convenience of reference and comparison, objects submitted for purchase are liable to be photographed (solely for official purposes and not for sale) unless an objection in writing be made by the owner at the time of the delivery of the objects. When photographs are taken, two copies will be given to the owner of the object photographed.

III.

Regulations for admission

The Museum is open daily, except on Good Friday and Christmas Day.

On Mondays, Tuesdays, and Saturdays, the whole of the Museum is open free from 10 a.m till 10 p.m.

On Wednesdays, Thursdays, and Fridays the Museum is open from 10 a.m. till 4, 5, or 6 p.m., according to the season. On these days, being "Students' Days," a charge of 6d. for admission to the Main Building is made for each person excepting Ticket Holders; but the Museum Buildings to the West of the Exhibition Road are open free.

On Sundays the whole of the Museum (excepting the Libraries) is open free from 2 p.m. till dusk.

Tickets of admission to the Museum (including the Libraries) can be obtained at the Main Entrance of the Museum at the following rates:—Weekly, 6d.; monthly, 1s. 6d.; quarterly, 3s.; yearly, 10s. Yearly tickets are also issued at £1, which will admit all the pupils of a private school.

All visitors who have paid on entrance, and all Ticket Holders are entitled to admission to the Libraries, which are open on week days during the same hours as the Museum (excepting the Dyce and Forster Library, which closes at 6 p.m. on Mondays, Tuesdays, and Saturdays).

Free tickets of admission are issued to teachers and students of Science and Art Schools, to donors and lenders to the Museum, to persons who are recognised by the Board as qualified to teach, to students at various public institutions, and to persons engaged

in professions or trades connected with the decorative arts, or with engineering, manufacturing, or other technical pursuits, upon satisfactory evidence that they are employed in, or studying for such careers.

IV.

Regulations for copying objects other than pictures.

(1.) When the Museum is open to the Public, persons are permitted to sketch, draw, or paint from those Art Objects, other than Paintings, that are the property of the Nation, so long as arrangements can be made for their so doing without inconvenience to other Visitors.

(2.) In the case of objects on loan, only persons who hold the written permission of the owner will be allowed to make sketches or drawings, and the letter of authority must be produced whenever it is asked for by an officer of the Museum.

(3.) If an easel be required it must be provided by the student, and should be removed before the closing of the Museums.

(4.) Students must not place their cloaks, hats, &c., on the cases or pedestals.

(5.) Step ladders or scaffolding will, when possible, be provided, if required. A written application for their use must be made to the Secretary, Board of Education, South Kensington, London, S.W.

V.

Regulations for copying pictures.

(1.) A Form of application for permission to copy pictures (see p. 272) is supplied by the Attendant in the Galleries, or will be sent in reply to a letter addressed to the Secretary, Board of Education, South Kensington, London, S.W. The form, when filled up, should be given to the Attendant, or sent by post, addressed as above.

(2.) In the case of pictures on loan, only persons who hold the written permission of the owners will be allowed to copy the pictures and the letter of authority must be produced whenever it is asked for by an officer of the Museum.

(3.) Permission which may be given to copy any work is subject to any copyright which may be claimed, but as to which the Board cannot undertake to give information or offer an opinion.

(4.) Applicants must, if required, send specimens of their work shewing their ability to avail themselves of the privilege desired.

(5.) Copying cannot be permitted except on Students' Days, and only a limited number of persons can be admitted at the same time to work in any apartment.

(6.) Only under exceptional circumstances can works be removed from the walls for the purpose of copying.

(7.) On shewing their permits to copy, or their admission cards, students may be allowed to use the lavatories of the Museum without charge, and they may wash their brushes there. This privilege does not apply to students of the Royal College of Art.

(8.) The Board do not take any responsibility with respect to canvases, easels, paint-boxes, etc., which may be left at the Museum.

(1.) Application for authority to take photographs in the Museum must be made in writing, addressed to the Secretary, Board of Education, South Kensington, London, S.W. **Regulations for photographing objects and pictures.**

(2.) Applicants must state the purposes for which the photographs to be taken are wanted, and if required, must furnish evidence of their proficiency in the art of photography.

(3.) Objects on loan can be photographed only on production of the written authority of the owner.

(4.) If the special circumstances of the case permit, permission will be granted to photograph Oil Paintings or Water Colour Drawings; but before permission to photograph objects or paintings is granted, a list of them quoting the registered number and title of each, must be submitted for approval.

(5.) The permission to take photographs is subject to any copyright. The Board cannot undertake to give information or offer an opinion on any claim to copyright.

(6.) On the list supplied by applicants it should be distinctly indicated if the objects are required to be removed from the glass cases or not. Small objects which can be safely and conveniently taken from the cases may be moved by Museum attendants to suitable positions for photographing, but no large or heavy objects can be moved, and no change in arrangement of objects can be made which may cause inconvenience to the public. The Museum attendant who moves an object will be present, and will remain in charge of it during the whole time required for photographing it, and he alone may handle it.

(7.) Two copies of each photograph taken are to be forwarded, as soon as possible after the proofs are printed, to the Secretary, Board of Education, South Kensington, London, S.W. This rule must be strictly attended to. For proper identification, the registered number of each object should be marked on the back of each proof.

VII.

Portfolios containing photographs of Paintings, Drawings, Works of Decorative Art, and of Machinery Models, etc., belonging to the Museum, or which have from time to time been exhibited in the Museum, may be seen at the catalogue stall. For the convenience of the public, the attendant at the catalogue stall will forward orders for prints, either mounted or unmounted, upon pre-payment of their cost to the Photographer. A tariff of sizes and prices of prints will be found at p. 273. **Photographs of paintings &c. may be seen and proofs purchased.**

VIII.

Under certain circumstances permission may be given to make Plaster Casts and Electrotype Reproductions of Works of Art in the Museum. **Permission may be given to make plaster casts, &c.**

X.

Publications. Lists of the Publications on sale at the catalogue stall in the Museum are given at p. 30.

The Bethnal Green Museum

V.

The Bethnal Green Museum. The Bethnal Green Museum includes the following collections:—

1. Illustrations of substances used as food.
2. Animal Products.
3. Illustrations of Economic Entomology.
4. Examples of Ornamental Art.
5. Oil and Water-colour Paintings.

XI.

Regulations for admission. The Museum is open free daily except on Good Friday and Christmas Day,

On Mondays, Thursdays, and Saturdays, from 10 a.m. till 10 p.m.

On Tuesdays, Wednesdays, and Fridays, from 10 a.m. till 4, 5, or 6 p.m., according to the Season.

On Sundays from 2 p.m. till dusk.

XII.

Other Regulations. Sections II., IV., V., VI., VIII., and IX. apply also to this Museum.

The Geological Museum, Jermyn Street.

XIII.

The Geological Museum, Jermyn Street. The Geological Museum, Jermyn Street, illustrates the Geological Structure and the Mineral Resources of the United Kingdom. It contains, *inter alia*, a collection of British Fossils, and a Petrographical Collection comprising a series of British Rock Specimens. A Library devoted to works on Geology, Palæontology, and Petrography is attached to the Museum.

XIV.

Regulations for admission. The Museum is open free on every week-day except on Good Friday and Christmas Day.

On Mondays, and Saturdays, from 10 a.m. to 10 p.m.

On Tuesdays, Wednesdays, Thursdays, and Fridays from 10 a.m. till 4 or 5 p.m., according to the Season.

On Sundays from 2 p.m. till 4 p.m., dusk, or 7 p.m., according to the Season.

Grants and Loans to Museums, Schools, etc.

XV.

Aid to Museums.

The Board of Education aid approved Provincial Museums by :—

(*a*) Grants towards the purchase of objects, see pages 274 to 276.

(*b*) Loans of objects selected from the Victoria and Albert Museum, see page 277.

XVI.

Aid to Educational Exhibitions. Aid to Schools.

The Board also aid Educational Exhibitions by the loan of selected objects, see pages 277 to 279 ; and Schools by the loan of objects, books, paintings, drawings, lantern slides, and of examples of students' work, etc., see pages 280 to 282.

In the case of approved Art Classes loans, except of students' works, are only made where there is a room wholly devoted to instruction in Art.

XVII.

Loans to Schools under Local Authorities.

Plaster Casts, Electrotypes, Photographs, etc., are lent to Schools under Local Authorities, whose control of such Schools is recognized by the Board, for short periods as indications of examples likely to be useful to their classes at which training in Art Crafts is given.

XVIII.

Safe custody and return of objects to be guaranteed.

Applicants for a loan are required to guarantee the safe custody and return of the objects lent, which must not be removed from the premises. In the case of Museums, the applicants are required to pay, in respect of the expenses, a fixed charge of fifty shillings for each van needed to convey the objects to the Museum, and to defray any local expenses ; any cost of carriage, other than local expenses, not covered by the fixed charge being borne by the Board. In the case of Schools or Educational Exhibitions, the applicants are required to defray the expenses of the carriage to the School or Educational Exhibition ; the cost of carriage on the return journey being borne by the Board.

The special requirements as to insurance and night watching of loans will be found at page 279.

PROSPECTUS

OF

HE ROYAL COLLEGE OF SCIENCE, LONDON,

WITH WHICH IS INCORPORATED

THE ROYAL SCHOOL OF MINES.

Session 1903-4.

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he Board of Education give notice that the arrangements detailed in this Prospectus are subject to such alterations in the course of the College Session, 1903-4, as may be found necessary.

PAST PROFESSORS OF THE ROYAL SCHOOL OF MINES AND ROYAL COLLEGE OF SCIENCE.

Chemistry.

1851–53. The Right Hon. Baron Playfair, of St. Andrews, P.C., G.C.B., LL.D., Ph.D., F.R.S.
1853–65. A. W. von Hofmann, Ph.D., LL.D., F.R.S.
1865–85. Sir Edward Frankland, K.C.B., M.D., D.C.L., LL.D., Ph.D., F.R.S.
1885–94. Thomas E. Thorpe, C.B., Ph.D., D.Sc., LL.D., F.R.S.

Physics.

1853–54. Robert Hunt, F.R.S.
1854–60. Sir George G. Stokes, Bart., D.C.L., LL.D., D Sc., F.R.S.
1860–68. John Tyndall, D.C.L., LL.D., F.R.S.
1868–86. Frederick Guthrie, Ph.D., F.R.S.
1886–01. Sir A. W. Rücker, M.A., D.Sc., F.R.S.

Astronomical Physics.

1881–01. Sir J. Norman Lockyer, K.C.B., F.R.S.

Mechanics and Mathematics.

1851–53. Robert Hunt, F.R.S. (Mechanical Science).
1853–69. The Revd. R. Willis, M.A., F.R.S.
1869–94. Thomas M. Goodeve, M.A., Barrister-at-Law.

Geology.

1851–76. Sir Andrew C. Ramsay, LL.D., F.R.S.

Biology.

1851–54. Edward Forbes, F.R.S.
1854–95. The Right Hon. T. H. Huxley, P.C., D.C.L., LL.D., F.R.S.

Metallurgy.

1851–79. John Percy, M.D., F.R.S.
1879–02. Sir W. Chandler Roberts Austen, K.C.B., F.R.S.

Mining.

1851–91. Sir Warington W. Smyth, F.R.S.

PAST DIRECTORS OF THE ROYAL SCHOOL OF MINES.

1851–55. Sir Henry T. De la Beche, F.R.S.
1855–71. Sir Roderick I. Murchison, Bart., K.C.B., D.C.L., LL.D., F.R.S.

LATE DEAN OF THE ROYAL COLLEGE OF SCIENCE AND ROYAL SCHOOL OF MINES.

1881–95. The Right Hon. Thomas H. Huxley, P.C., D.C.L., LL.D., F.R.S.

INTRODUCTION.

Extract from the First Report of the Normal School of Science and Royal School of Mines, Session* 1881-82, *by the late Dean, Prof. T. H. Huxley, F.R.S.*

"The Normal School of Science and Royal School of Mines is the result of the organisation into one body of two systems of instruction, directly or indirectly related to technical education, which at different times, and independently of one another, have been constituted by the State.

The older of these is the technical school for mining and other branches of industry, especially chemical manufactures, which was established in 1851, in connexion with the Museum of Practical Geology in Jermyn Street, under the title of 'The Government School of Mines and of Science applied to the Arts.

One of the effects of the Great Exhibition of 1851 was the creation of a demand for scientific technical education; and, in 1853, the newly formed Department of Science and Art endeavoured to meet that demand, by widening the scope of the Jermyn Street School and giving it the character of a centre for a prospective system of technical education of which the Mining School would naturally form only one branch. The system of instruction was reorganised in this sense, and the name of the school was changed to 'The Metropolitan School of Science applied to Mining and the Arts.'

Had this scheme been carried out, the establishment of a general system of technical education, which the pressure of necessity is now slowly forcing upon the country, would have been anticipated by 30 years. But adverse influences prevailed; in 1859, the general and technical divisions of the school were abolished; the courses of instruction for associates were restricted to a mining, a metallurgical and a geological division; and, though the instruction in chemistry retained a 'special reference to the applications of chemistry to the Arts and Manufactures,' the institution was, as far as possible, reduced to a School of Mines, pure and simple. In accordance with this change, the title of the school was once more altered, first to 'Government School of Mines,' and subsequently to 'Royal School of Mines.' This last modification was effected in 1863.

The Museum of Practical Geology in which the institution was lodged was totally unfit for the purposes of a school; and, within two years of the creation of the School of Mines, accommodation for chemical and metallurgical laboratories had to be sought outside the building in Jermyn Street. In the other branches of physical science taught in the school practical instruction was impossible, in the absence of both the space and the appliances requisite for the purpose, and there was no provision for instruction in mathematics.

* The title was changed from "Normal School of Science" to the Royal College of Science, London, on the 25th October, 1890.

This state of things lasted until 1872, when, on the unanimous recommendation of the Council of the Royal School of Mines, the professors of chemistry, physics and biology were transferred to the premises at South Kensington which they at present occupy; and in which it became possible for the first to complete, and for the last two to institute, a system of laboratory instruction for their students. Subsequently, the professors of geology, metallurgy, and applied mechanics followed their colleagues; and at present, only the instruction in mining is given in Jermyn Street.*

These changes have in no way interfered with the existence or the efficiency of the Royal School of Mines. On the contrary, the course of instruction through which students desiring to obtain the associateship of the school must pass is immeasurably improved, by the addition of mathematics; by the far more thorough instruction in applied mechanics and mechanical drawing; by the addition of systematic laboratory instruction in physics, biology, and geology; and by the far better accommodation for the students of chemistry, and especially for those of metallurgy, which is afforded at South Kensington.

The younger system of instruction is the Normal School of Science, which has arisen out of the organisation for elementary scientific teaching and examination established by the Science and Art Department in 1859. It was, from the first, an essential part of that organisation that candidates who highly distinguished themselves in the examinations should have the opportunity of developing the scientific capacity they had shown; and exhibitions were provided for their maintenance while pursuing their studies in the Royal School of Mines and elsewhere.

But it was very soon discovered that the instruction given in the science classes was extremely defective, and that the main obstacle in the way of its improvement lay in the ignorance of the proper methods of scientific teaching which prevailed among the teachers of the classes.

As a partial remedy for this evil, teachers have been encouraged, year after year, to attend short special courses of lectures and laboratory work in the various branches of physical science taught in the Royal School of Mines.

But it is obvious that, if the elementary science teaching in the country is to be made thoroughly satisfactory, the teachers must be efficiently trained, and training of this kind involves a lengthened period of systematic theoretical and practical instruction. It is the chief object of the Normal School of Science to provide such instruction for the teachers of the subjects of the May examinations in physical science, except those which are dealt with by the schools of navigation and naval architecture.

The Normal School of Science, the objects of which have just been defined, was created last year, by adding to the existing staff of the Royal School of Mines lecturers on Mathematics, Astronomy, Botany, and Agriculture; and by making provision for practical instruction by the appointment of additional demonstrators and assistants.

The Normal School of Science and Royal School of Mines is administered by a Council, consisting of the Professors of Mechanics, Physics, Chemistry, Biology, Geology, Metallurgy, and Mining, with the Lecturers† on Physical Astronomy and Agriculture. One of the Professors is appointed Dean by the Lord President, and the administrative work of the school is carried out by a Registrar.

Instruction is given in the school in the following subjects:—

Mechanics and Mathematics, Physics, Chemistry, Biology and

* All the instruction is now given at South Kensington.

† These posts are now abolished.

Botany, Geology and Mineralogy, Agriculture, * Metallurgy and Assaying, Mining, Elements of Astronomical Physics, Practical Geometry, Mechanical Drawing and Freehand Drawing.

Occasional students may enter for any course of instruction, or for any number of courses, in such order as they please; but students who desire to become Associates of the Normal School of Science, or of the Royal School of Mines, must follow a prescribed order of study, which occupies from three to three and a half years.

"In the first two years, the students must all go through the same instruction in Mechanics and Mathematics, Physics, Chemistry, Elementary Geology, Astronomy, and Mineralogy, with Drawing; afterwards they must elect to pass out in one or other of the eight divisions, to the subjects of which the third and fourth years' studies are entirely devoted, namely:—I. Mechanics; II. Physics; III. Chemistry; IV. Biology; V. Geology; VI. Agriculture**; VII. Metallurgy; and VIII. Mining.

A student who passes in all the subjects of the first two years, and in the final subjects of Divisions I., II., III. IV., V., or VI., becomes an Associate of the Normal School of Science; while, if he takes the final subjects of Divisions VII. or VIII., he becomes an associate of the Royal School of Mines.

The work of the school is arranged in such a manner as to permit the student to concentrate his attention upon one subject at a time, and he is never occupied with the subjects of more than two divisions in the same term. By far the greater part of his time is devoted to practical work in the laboratories, under the demonstrators and assistants.

The examinations in the subjects of each year are held within that year, so that the final examinations are confined to the special subjects of the division in which the candidate seeks for the associate-ship."

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* The Subject of Agriculture was withdrawn from the Syllabus, Session 1897-98.

** The course of instruction in the Second Year is now modified to suit the requirements of students taking different subjects in their Third Year.

Session 1903-4.

PROSPECTUS

OF THE

ROYAL COLLEGE OF SCIENCE, LONDON,*

WITH WHICH IS INCORPORATED

THE ROYAL SCHOOL OF MINES.

1. The Royal College of Science at South Kensington is a non-residential institution supported by the State to supply systematic instruction in the various branches of Physical Science to students of all classes. While the College is primarily intended for the instruction of Teachers, and of students of the industrial classes selected by competition in the examinations of the Board of Education, South Kensington, other students are admitted so far as there may be accommodation for them (*see* § 15), on the payment of fees fixed at a scale sufficiently high to prevent undue competition with institutions which do not receive State aid.

2. The Royal School of Mines is incorporated with the Royal College of Science. Students entering for the Associateship of the Royal School of Mines obtain their general scientific training in the Royal College of Science.

3. The instruction in the Royal College of Science is controlled by a Council consisting of the Professors, with a Dean as Chairman. A Registrar, who acts as Secretary to the Council, is responsible for the general discipline of the students.

4. The instruction in the Royal College of Science is arranged in such a manner as to give the students a thorough training in the general principles of Science, followed by advanced instruction in one or more special branches of Science.

5. The Associateship is granted in certain divisions or lines of study. Students who go through any one of these divisions, taking the subjects of instruction in the prescribed order and who pass the necessary Examinations, receive a Certificate of Associateship of the Royal College of Science or of the Royal School of Mines.

* The title was changed from "Normal School of Science" on the 25th October, 1890.

6. Students who are not candidates for the Associateship are permitted to enter as occasional students in one or more special branches of Science, providing they possess some preliminary knowledge of the subject they propose studying, and so far as there is room. Certificates will not be granted to occasional students who pass the examinations in Mining and Metallurgy, and certificates are not given for Drawing, nor for Mathematics, except in the higher classes, namely, C, D, and E.

7. The Associateship of the Royal College of Science is given in one or more of the following divisions—

Mechanics,
Physics,
Chemistry,
Biology,
Geology,

and the Associateship of the Royal School of Mines in—

Metallurgy,
Mining.

8. The course of instruction, which lasts for three years, is the same for all the divisions during the first year, after which it is specialised in accordance with the Scheme given on pages 16 and 17, where the fee for each section of the course is also stated.

9. A student obtains the Associateship who passes in all the subjects of the first year, and, in the second and third year, those subjects prescribed as necessary for the division in which he seeks to obtain his Associateship.

The obligation to go through the Elementary, or First Part in any of the courses, may be remitted in the case of any student who satisfies the Council that he has received sufficient theoretical and practical instruction in those subjects.

10. The Associateship in Mining will not be awarded to a student until he has completed, in all, six months practical experience of underground work in a Mine; of this, one half at least must be completed before the student attends the lectures on Mining. (See also p. 97.)

11. No student can take the double Associateship in Mining and Metallurgy in the same year unless he satisfies the Council at the commencement of the third year's session that his previous training in one or both of those subjects is such as to warrant a departure from the ordinary rule.

12. Students who have failed to satisfy the Examiners at the end of their period of study in an Elementary class, will not be allowed to enter the Advanced Course in the same subject until they have passed the Elementary Examination.

13. No candidate for the Associateship will be allowed to proceed to the work of the Second Year unless he has passed the Examination in Mathematics (Class A.), nor can he enter a Third Year's Course unless he has passed the Examination in at least three of the preliminary subjects of the first two years, namely, Chemistry, Physics, Mechanics or Biology, and Geology, nor unless he has acquired the amount of Mathematical knowledge essential in the opinion of the Professor in charge of the Class he proposes to attend.

ASSOCIATESHIP COURSE.

FIRST YEAR.

First Term.	*Second Term.*
Chemistry (part I.) 16*l.*	Physics (part I.) 17*l.*

Mathematics 3*l.* (per Term).
Drawing, 1*l.* (per Term).

Students who do not already possess a practical knowledge of Mining and who propose to take the Associateship in that subject are expected to obtain, during the vacations of the two first years of study in the College, some practical instruction in Mines.

SECOND YEAR.

First Term.	*Second Term.*
A. Mechanics and Machine Drawing (part I.) 13*l.*	Geology (part I. including Mineralogy) 12*l.*

Applied Electricity 5*l.* (*per Session*).

B. Biology (part I.) 17*l.*
Mathematics (so far as necessary) 3*l.* (per Term).
Descriptive Geometry (including Graphics) 3*l.* (per Session).

NOTE.—A. for students who intend taking the Associateship in the Divisions of Mechanics, Physics, Chemistry, Metallurgy, or Mining. Applied Electricity is an optional subject for students who intend taking the Associateship in Chemistry.

B. for Students who intend taking the Associateship in the Divisions of Biology or Geology.

Descriptive Geometry is an optional subject for those students who take B.

THIRD YEAR.

First Term.	*Second Term.*
Mechanics.	
Mechanics (part II.) 8*l.*	Mechanics (part III.) 8*l.*
Mathematics 3*l.*	Mathematics 3*l.*
Machine Drawing 3*l.*	Machine Drawing 3*l.*

13—*cont.*

First Term.	*Second Term.*

Physics.

Physics (parts II. & III.) 12*l.*	Physics (parts II. & III.) 12*l.*

Chemistry.

Chemistry (part II.) 16*l.*	Chemistry (part III.) 16*l.*

Biology.

Zoology (parts II. & III.) 12*l.*	Zoology (parts II. & III) 12*l.*
Botany (part III.) 12*l.*	Botany (part III.) 12*l.*

Geology.

Geology (part II.) 8*l.*	Geology (part III.) 8*l.*

Metallurgy.

Metallurgy lectures (part I.) 2*l.*	Metallurgy lectures (part II.) 2*l.*
Assaying 13*l.*	Assaying 13*l.*
Dressing of Minerals.	

Mining.

Mining lectures.	Mining lectures, 4*l.* for session.
Metallurgy (part I.) 2*l.*	
Assaying 13*l.*	Mine Surveying 10*l.*

TEACHING ASSOCIATES.

14. A limited number of students, who have already obtained the ordinary Associateship of the College in any division, will be granted the title of Teaching Associate in that division upon the conditions stated below.

Teachers-in-training or private students, who have passed with credit through the whole course of instruction in any division of the College may be granted the same title on the like conditions, provided that they satisfy the Council, by their having passed certain University or other examinations, that they have had a sufficiently good general training.

14—*cont.*

The course of training for the Teaching Associateship of the College is recognised for the purposes of Appendix D of the Teachers' Registration Regulations.

(1) The limit to the number of candidates selected for admission to the course of study preparatory to associateships in teaching will be settled with reference to the number of assistant teachers whose services can be utilized in the College.

(2) Candidates will be selected by the Council, regard being had both to their intellectual qualifications and as to whether they are in the opinion of the Council likely to be good teachers.

(3) Candidates will be required to assist in the College work for at least two sessions, under conditions hereinafter laid down, it being at the discretion of the professor under whom that work is carried on to determine the proportion of time to be devoted to actual demonstration and to study as a preparation for teaching respectively.

(4) The instruction of candidates for the title of Teaching Associate will be given in the several divisions of the College.

(5) Each candidate, besides passing two sessions in one of the laboratories of the College as a student-assistant, shall be assisted in acquiring skill in the art of teaching by the following methods:—

(6) He shall assist the regular lecture attendant to prepare a number (say 10) of an elementary course of lectures, or shall attend a short course of demonstrations on the preparation of lecture-experiments, or shall prepare to the satisfaction of the professor a certain number of specimens or pieces of apparatus suitable for the illustration of lectures.

(7) He shall prepare a certain number of diagrams and photographic or other lantern slides.

(8) The candidate (either during the period that he spends in the College, or before receiving his title of Teaching Associate) shall teach a science subject in some Institution under the inspection of the Board of Education for at least one session, taking charge either of a science class in an approved Evening School or a class in a Day School. A report upon the teaching then given will be made to the Board by one of H.M. Inspectors. In lieu of

14 (8)—*cont.*

the above and under certain specified conditions, candidates may be allowed to give instruction to classes in the College.

(9) Candidates shall also be required to visit science classes and to submit to the Inspector for his criticism a detailed report on the instruction to which they have listened.

(10) The work done outside the College will be reported upon by the Inspectors of the Board of Education.

(11) Candidates for the Associateship in teaching any subject will be required to attend the teachers' summer course of instruction upon the method of teaching which the Professor of that subject will give.

(12) They shall also attend the course of lectures on Education at the London University.

Admission of Students.

15. Application for admission in the session commencing in October must be made on Form 1289, and be sent to the Registrar before the middle of June. In this form a statement should be given of the studies which the applicant has already pursued, the examinations he has passed, and the names of a teacher or teachers to whom reference may be made. This application will be considered by the Dean and Council of the College, who will decide whether or not the candidate can be admitted.

Students must be free from organic disease and physical defect that would interfere with their studies, and a medical certificate to this effect may be required.

Form 1289 can be obtained on application in writing to the Registrar.

This paragraph applies to private, *i.e.*, fee-paying Students only. The regulations as to the admission of State-aided Students are contained in paragraphs 29 to 31.

16. Without some preliminary knowledge of Mathematics, Mechanics, Chemistry, and Physics it is not possible for Students to follow the Courses with advantage. No fee-paying Student will be entered for the Associateship Course unless he has obtained a First Class in the First Stage of Mathematics, or the First Stage of Practical Mathematics; and in the First Stage of Practical Plane and Solid Geometry, Theoretical Mechanics (Solids), Theoretical Mechanics (Fluids), Inorganic Chemistry (Theoretical), Sound, Light, and Heat, and Magnetism and Electricity,

16—*cont.*
or a pass in some higher stage of those subjects, at the Examinations of the Board of Education,* or can show to the satisfaction of the Council of the College, by having passed the Examinations of other recognised Institutions or Examining bodies, that he possesses the necessary elementary knowledge of those subjects, while for occasional students who desire only to take up certain specific branches of Science some preliminary knowledge of such subject will be required.

17. Admission is granted to persons desirous of attending certain courses of the lectures without the laboratory instruction, on payment of the lecture fees.

18. Students who do not wish to attend the lectures are admitted for short periods to the laboratories, at the discretion of the Professors. The fees for the laboratories are 4*l.* per month.

19. Officers of the Army, Navy, and Civil Service, recommended by their respective Departments, are admitted to the Lectures and Laboratories at half fees.

20. *Bonâ fide* teachers who are recognised as qualified to teach, and who are actually engaged in teaching, or have recently taught approved Science or Art Classes under the Board, may be permitted to attend free any course of lectures on application to the Registrar.

21. Associates of the Royal College of Science or of the Royal School of Mines have the privilege of free admission to the Library and to all the courses of lectures.

Times of Study.

22. The Session is divided into two Terms. The first Term begins on the 7th October and ends about the middle of February. The second Term begins in the middle of February and ends about the middle of June. The Christmas and Easter Holidays each last about a fortnight.

23. The hours of study are from 10 a.m. to 1.15 p.m., and from 2 to 4 or 5 p.m., according to the subject of study, every day, except on Wednesday and Saturday, when the College closes at 1 p.m.

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* *Enquiries relating to these Examinations, which are held annually in May and June, should be addressed to the Secretary, Board of Education, South Kensington, London, S.W.*

Fees.

24. The fees of students entering for the Associateship are given, for greater convenience, on pages 16 and 17, from which it will be seen that the total for the first two years amounts to about 70*l.*, and for the remainder of the course for the Associateship they vary from 30*l.* to 40*l.* Students not entering for the Associateship are admitted to any particular course of study, so far as there is room, on payment of the fees, as shewn in the following table:—

	£
Applied Electricity, per session - - -	5
Biology (Botany and Zoology). Lectures -	5
„ Laboratories, per term - - -	12
Chemistry, Inorganic. Lectures - - -	3
„ Organic „ - - -	3
„ Laboratories, per term - -	13
Geology, including Mineralogy. Lectures -	4
„ Laboratories, per term - - -	8
Mechanics. Part I. Lectures - - -	4
„ Elementary Class-work, per term	6
„ Advanced Lectures and Class-work, per term - - -	8
Metallurgy. Lectures, per term - - -	2
„ Laboratories, per term - -	13
Mining, Principles of. Lectures - - -	4
Mine Surveying - - - - - -	10
Physics. Part I. Lectures - - - -	5
„ Laboratories, per term - - -	12

N.B.—*In all cases fees must be paid in advance.*

Examinations.

25. Examinations are held at the end of each course of instruction and at such other periods as may be found necessary. These examinations will be conducted by the Professors conjointly with Examiners appointed by the Board of Education. On the results of these examinations, the successful candidates who have attended regularly and otherwise conformed to the rules of the College are arranged in two classes, first and second. The following is the Scale of Marks authorised for the examinations in the subjects of the first two years:—

Mathematics	Class A. - -	10
	„ B. - -	15
	„ C. - -	30
	„ D. - -	45
		100

25—*cont.*

FIRST YEAR.

First Term.	*Second Term.*
Chemistry (part I.) - 100	Physics (part I.) - 100
Mathematics, according to scale.	Mathematics, according to scale.

For a *Pass* in Drawing according to the special course prescribed for students of the College - 10

SECOND YEAR.

First Term.	*Second Term.*
A. Mechanics and Machine Drawing (part I.) - - 100	Geology, Elementary, and Mineralogy - 100
B. Elementary Biology 100	Mathematics, according to scale.
Mathematics, according to scale.	

Descriptive Geometry - 20

For a *Pass* in Applied Electricity according to the special course prescribed - 30

26. There are also "Honours" examinations for the subjects of the third year, the successful candidates being placed in order of merit.

"Honours" are only obtainable by Candidates for the Associateship. No one will be allowed to attempt the Honours examination who fails to obtain a First Class in the ordinary examination.

The Candidate for Honours will be required to pass an examination in some special branch or branches of one of the subjects in which the Associateship can be taken. The papers set will be of a more advanced character than those in the ordinary Associateship Examination.

The Candidate will also be required to present a Thesis on some special subject, and great weight will be given to the adequate description of any original work or research which has been carried out by the Student in one of the laboratories of the College with the sanction of the Professor.

For the Honours Examination in certain divisions the subjects will be as follows, and the student will only be required to take up one of these:—

Division II.—Physics.	*Division III.—Chemistry.*
Sound and Light.	Inorganic Chemistry.
Heat.	Organic Chemistry.
Electricity and Magnetism.	Chemical Physics.
Chemical Physics.	

26—*cont.*

The examination in Chemical Physics will be held jointly by the Professors of Chemistry and Physics.

Division IV.—Biology.

Zoology.	*Botany.*
Anatomy and Histology.	Physiology of Plants.
Development.	Anatomy and Histology.
Vertebrate Palæontology.	Morphology in relation to Classification.

Division V.—Geology.

Petrology.	Stratigraphical Geology.
Invertebrate Palæontology.	

Division VII.—Metallurgy.

Researches connected with the practical Examination of a Metallurgical process or details of a process.
Theoretical Metallurgy.

Division VIII.—Mining.

Geological and technical description of some mine or mining district from personal study, with full details.

RE-EXAMINATION.

27. Students may be re-examined on payment of a fee of 1*l.* for each subject.

CERTIFICATES.

28. A student who goes through the prescribed course of instruction in any subject, excepting Mining and Metallurgy, and passes the final examination in it, receives a certificate to that effect as an occasional student.

ROYAL EXHIBITIONS, NATIONAL SCHOLARSHIPS, AND FREE STUDENTSHIPS.

29. Royal Exhibitions, National Scholarships, and Free Studentships are open only to British subjects, and the Board may refuse to award them to persons whose financial circumstances do not warrant such aid. The Exhibitions and Scholarships can only be held concurrently with Scholarships granted by County Councils, with the express sanction of the Board, who will consider the reasons urged. The Board may withhold any of these awards should the standard of the candidates' attainments be unsatisfactory, or may transfer them to other groups in the current competition. Exhibitions, Scholarships etc.

Where the conditions of Exhibitions or Scholarships have been modified the interests of existing Exhibitioners and Scholarship holders will not be adversely affected.

29—*cont.*

a. Twenty-one Royal Exhibitions—seven open each year—and Sixty-six National Scholarships—twenty-two open each year—tenable at the option of the holder at either the Royal College of Science, London, or the Royal College of Science, Dublin.

Eighteen Free Studentships—six open each year—to the Royal College of Science, London.

b. The award of all the Exhibitions, Scholarships, and Studentships is made on the results of the Evening Examinations of the Board for the current year, and previous successes are not counted. The Exhibitions, Scholarships, and Studentships are held on the condition that the holder attends the prescribed course of instruction regularly, complies with all the rules, and passes the prescribed examinations.

c. Competitors for Royal Exhibitions, National Scholarships, or Free Studentships must arrange before March for their examinations (*see* § 65, p. 22 of Regulations for Evening Schools, Technical Institutions, and Schools of Art and Art Classes) and must send in Form 330*a* before the 15th April, and Form 400 before the 10th June.

Students in training and Science students who have been for more than one session in the Royal College of Science, London or Dublin, are not eligible for Royal Exhibitions, National Scholarships, or Free Studentships.

A candidate who has held either a Royal Exhibition, a National Scholarship, or a Free Studentship, is ineligible to enter into further competition for these awards. No candidate can hold concurrently a Royal Exhibition and a National Scholarship, and no Local Science and Art Exhibitioner can hold concurrently a Royal Exhibition, a National Scholarship, or a Free Studentship.

yal Exhi-tions.

d. A Royal Exhibition entitles the holder to an allowance of 50*l.* a session, and free admission to lectures and laboratories and instruction during the three years necessary for completing the Associateship course in the Royal College of Science, London, or the Royal College of Science, Dublin.

tional holarships.

e. A National Scholarship entitles the holder to an allowance of 25*s.* a week for the session of about forty weeks each year, and free admission to lectures and laboratories and instruction during the three years necessary for completing the Associateship course at either the Royal College of Science, London, or the Royal College of Science, Dublin, at the option of the holder.

29 (*e*)—*cont.*

Should a Royal Exhibitioner or National Scholar be required to assist in teaching in the Royal College of Science, he will receive, while so employed, an additional weekly payment of 5*s*.

f. A Free Studentship entitles the holder to free admission to the lectures and laboratories and to instruction during the three years necessary for completing the Associateship course in the Royal College of Science, London. Free Studentships.

g. Third class railway fare is allowed by the Board for one journey to and fro each session, between the home of the Royal Exhibitioner or National Scholar and London or Dublin, as the case may be. Third class railway fare is allowed by the Board for one journey to London to holders of Free Studentships upon their taking up their Free Studentship.

h. In these competitions the awards are determined in accordance with the following scale of marks:— Scale of Marks.

The maximum number of marks obtainable in each subject, except Mathematics, is:—

Stage 2 - - - - -	200
Stage 3 - - - - - -	300
Honours - - - - -	400

with half the above maximum marks for Practical Chemistry or Practical Metallurgy, or the Practical Honours Examinations held in accordance with the regulations (see § 57 (*b*), p. 18 of Regulations for Evening Schools, Technical Institutions, and Schools of Art and Art Classes) in addition to those for the Theoretical division of the same subject.

Marks will only be counted for Stage 2, or Stage 3, or Honours in a subject in any one competition.

In the case of subjects the Honours Examinations in which are amalgamated, as in VI*a*., VI*b*. and in X*p*., XI*p*., the marks awarded will be double those awarded where the subjects are not so amalgamated.

In Mathematics the numbers are:—

Division I.	2nd stage, or Practical Mathematics, stage 2 or stage 3 respectively	200
	3rd „ - - - -	300
	4th „ - - - -	300
Honours - -	- - - - -	500
Division II.	5th stage - - - -	300
	6th „ - - - -	300
	7th „ - - - -	400
Honours - -	- - - - - -	600

29*h*—*cont.*

In Mathematics, competitors may take on each of the evenings of Examination, one Stage or Honours, but no candidate can count marks both in Stage 2 of Practical Mathematics, and in Mathematics, Stages 2, 3, or 4.

In determining a candidate's position his marks are diminished in Stage 2 by 40 per cent., and in Stage 3 or in Honours by 30 per cent. of the maximum allotted in each case.

No candidate will be awarded a Royal Exhibition who has not obtained in Mathematics a success in the second or some higher stage, or a pass in Honours or in Practical Mathematics, Stage 2. This success may have been obtained in a previous year, but no marks are counted except for successes obtained in the current year.

oyal xhibition. In the competition for a Royal Exhibition, candidates may select their own subjects for examination, provided that, where the examination in more than one subject is held on the same evening, only one of such subjects is taken.

j. For the National Scholarships and Free Studentships the subjects for competition are divided into five groups, as given below:—

GROUP A.—*Mechanics.*

Mathematics, Stage 2, or 3, or 4, or Practical Mathematics, Stage 2, or Stage 3.
Mathematics, Stage 5, or 6, or 7.
Theoretical Mechanics (Solids).
Theoretical Mechanics (Fluids).
Applied Mechanics.
Steam.
Machine Construction,
or
Building Construction,
or
Naval Architecture.

GROUP B.—*Physics.*

Mathematics, Stage 2, or 3, or 4, or Practical Mathematics, Stage 3.
Mathematics, Stage 5, or 6, or 7.
Sound.
Light.
Heat.
Magnetism and Electricity.
Inorganic Chemistry, Theoretical and Practical.

GROUP C.—*Chemistry.*

Mathematics, Stage 2, or 3, or 4, or Practical Mathematics, Stage 3.
Mathematics, Stage 5, or 6, or 7.

29 (*j*)—*cont.*

Heat,
or
Magnetism and Electricity.
Inorganic Chemistry, Theoretical and Practical.
Organic Chemistry, Theoretical and Practical,
or
Metallurgy, Theoretical and Practical.

GROUP D.—*Biology.*

General Biology.
Human Physiology.
Zoology.
Botany.

GROUP E.—*Geology.*

Geology.
Mineralogy.
Zoology.
Botany.

k. A candidate may not compete in more than one of the five groups, and must state beforehand the group in which he elects to compete. He may take all the subjects in the group selected, except in the case of alternative subjects, only one of which may be taken.

l. No candidate will be permitted to take up his Exhibition, Scholarship, or Studentship until he has satisfied the Council of the Royal College of Science, by examination or otherwise, that he possesses such literary qualifications and knowledge of Mathematics, Mechanics, Chemistry, and Physics as to render it possible for him to follow the College course with advantage. A first class in the first stage of Mathematics, and a first class in stage 1 of Mechanics, Chemistry, and Physics obtained at the Board's Examinations will be accepted as sufficient qualification in Science. Third-class railway fare for one journey to and fro between the home of the candidate and London will be allowed in the case of candidates who fail to satisfy the Council.

m. Five National Scholarships will be allotted for competition in each of Groups A. and B., six in C., and three in each of D. and E. Two Free Studentships will be allotted for competition in Group A., and one in each of the other Groups.

The National Scholar or Free Student will, as a rule, uired to take for his second and third year's course in

29 (*n*)—*cont.*
the Royal College of Science, London, the Division corresponding to the Group in which he obtained his Scholarship or Studentship.

Studentships in Training.

30. A limited number of Teachers, and of Students in Science Classes who intend to become Science Teachers, are admitted free for a term or session to the Sessional Courses of instruction in the Royal College of Science as Students in training. They may be called upon to pass an entrance examination at the College in order to show that they possess such literary knowledge as to render it possible for them to follow the courses with advantage. Whilst under examination or instruction they will receive an allowance at the rate of 25*s.* per week, and third class railway fare for one journey to and fro between the home of the teacher or student and London. Should a Science Student in training be required to assist in teaching in the College he will receive, while so employed, an additional weekly payment of 5s.

Students in Training are sent to the College to attend special courses; in addition, however, they will be required to attend the classes for Mathematics, Descriptive Geometry, and Drawing so far as may be considered necessary.

Candidates for these Studentships in Training must send in Form 400 before the 10th of June, and Form 1019 before the 1st of July.

Local Exhibitions.

31. The rules under which Local Exhibitions to which the locality contributes 25*l.* and the State 25*l.* are granted will be found in §76, p. 26 of the Regulations for Evening Schools, Technical Institutions, and Schools of Art and Art Classes.

Free instruction is given to Local Exhibitioners who attend the College. Local Exhibitioners attend such courses as they select, or as are arranged for them by the locality providing the Exhibition, and their mathematical instruction must depend upon this.

No Local Exhibitioner will be permitted to take up his Exhibition until he has satisfied the Council of the Royal College of Science that he possesses such preliminary knowledge as will render it possible for him to follow with advantage the proposed course of instruction.

For any further information required relating to §§ 29 to 31, application should be made to the Secretary, Board of Education, South Kensington, London, S. W.

Rewards to Students.

Royal Scholarships.

32. Four Scholarships, of 15*l.* each, are given to the students who have gained the greatest aggregate of marks in the examinations of the first year; and two Scholarships of 25*l.* to those students who have gained the greatest number of marks in the examinations of the first two years.

These Scholarships are held on the condition that the students attend the courses of instruction regularly, are examined, and pass satisfactorily.

The Scholar receives one moiety of his Scholarship at the commencement of the Session and the balance at its conclusion if the conditions have been satisfied.

Teaching Scholarships in Chemistry.

33. Two Scholarships of 50*l.* each will be awarded annually to two students in the Chemistry Classes who take a high place in the final examinations of any previous Session, and who are otherwise, in the opinion of the Council, well qualified. Preference will usually be given to students who have completed their course in the Session immediately preceding.

The holders of these Scholarships will be required to teach in the Chemical Laboratories during the ensuing Session.

The Edward Forbes Medal and Prize.

34. The Trustees of the Edward Forbes Memorial Fund present a bronze medal and a prize of books, to be awarded to the Student who does best in Biology.

The Murchison Medal and Prize.

35. This Medal and prize of books, the gift of the late Sir Roderick Murchison, is awarded annually to the student who does best in Geology.

The Tyndall Prize.

36. The late Professor Tyndall, having presented a sum of 100*l.*, the interest of which is to be given as a prize, books to that value are awarded to the student who does best in Physics, Part I.

The De la Beche Medal.

37. This Bronze Medal, established in memory of Sir Henry De la Beche, is awarded annually to the student who does best in Mining.

The Bessemer Medal and Prize.

38. A Bronze Medal and a prize of books to the value of 5*l.*, given by Sir Henry Bessemer, are awarded annually to the student who does best in Metallurgy.

The Frank Hatton Prize.

39. A prize in memory of the late Frank Hatton, a former student of this school, will be given to the student who does best in Chemistry.

The Warington Smyth Medal and Prize.

40. A silver-gilt medal, and the balance of the proceeds of a fund established in memory of the late Sir Warington W. Smyth, are awarded annually to the student who takes his Associateship in the first class in Mining, and who has likewise passed the examination in either Metallurgy, Geology, or Mechanics in the first class, and who has sent in, after personal study, the best geological and technical description of some mine or mining district with full details, or the best description, with drawings, of some machinery used in or about mines, or of some process used at mines for preparing minerals for the market.

The Edward Matthey Prize.

41. The proceeds of a gift of 300 guineas from Edward Matthey, Esq., is awarded each year to the Associate of the Royal School of Mines who has conducted in the Metallurgical Laboratory a research which, in the opinion of the Council, is of sufficient merit to deserve the prize, the sum to be expended in the purchase of books or instruments, or in some other way approved by the Professor of Metallurgy.

Institution of Mining and Metallurgy Scholarships.

42. The Scholarships are of the annual value of 50*l.*, and are open only to Associates of the Royal School of Mines.

One of the two Scholarships shall be given in the Metallurgical Division, and one in the Mining Division, every year. If, however, there is no well-qualified candidate in one of these Divisions, the Council shall have the right to award both Scholarships in the other.

CONDITIONS FOR ELECTION.

1. The candidate shall not be eligible unless he is under 25 years of age, except under special circumstances to be decided by the Council.

42—*cont.*

2. The candidate shall have completed the course for the Associateship within two academical years of the award.

3. The candidate shall have passed First Class in Mining or in Metallurgy.

4. In making the award the means of the students shall be taken into consideration as far as possible.

CONDITIONS WHILE HOLDING THE SCHOLARSHIP.

5. The student shall procure a medical certificate stating that he is fit for the work in which he is about to be employed, and, if employed abroad, for the country in which he is about to live.

6. While holding the Scholarship the student shall reside and work at some mine or metallurgical works to be approved of by the Council, and shall keep a full diary and record of his work day by day, which shall be submitted to the Professor of the Mining or Metallurgical Division from time to time.

7. The Scholarship shall be withdrawn by the Council if at any time the holder's work or conduct is found to be unsatisfactory.

The Huxley Laboratory for Biological Research, and the Marshall Scholarship.

43. The research laboratory, founded to commemorate the long connexion of Professor Huxley with the Royal School of Mines and the Royal College of Science, is supplied with a valuable library given by him to the Institution, and is capable of accommodating two students. The occupants of this laboratory are required to undertake some branch of original research in Biology (Zoology, Botany, or Palæontology), under the superintendence of the professors in the Biological and Geological Divisions.

The Marshall Scholarship, which was founded by Miss Sarah Marshall in honour of her father, the late Mr. Mathew Marshall, of the Bank of England, is awarded annually to a student engaged in biological research in the Huxley Laboratory. The funds for this scholarship are supplied from the interest of 1,000*l* left by Miss Marshall for its endowment.

The Huxley Gold Medal.

44. This medal, the gift of the Huxley Memorial Committee, will be awarded annually to some person who is or has been a student in the College and shall have been selected for his ability to carry on research in some branch of Natural Science in which the late Professor Huxley was distinguished.

44—*cont.*

For the Gold Medal a silver-gilt medal may, at the option of the Medallist, be substituted, the balance of the interest of the invested capital being either devoted to the purchase of books or given in aid of research in the Huxley Laboratory.

Prizes given by the Board of Education.

45. Prizes of books, each of the value of 3*l.*, are awarded by the Board of Education to the students who do best in the following subjects:—Mechanics, Mathematics, Physics, Practical Chemistry, Mining.

46. It rests with the Council to determine which of the candidates for the foregoing Medals and Prizes have done best, but no award will be made unless the candidate is considered to have shown sufficient merit. No candidate is allowed to compete for the same prize more than once.

SUMMER COURSES FOR TEACHERS.

47. Short courses of instruction are given annually, about July, in different branches of Science, for a limited number of Science Teachers. The courses last three weeks. The teachers who attend receive third class railway fare to and from South Kensington, and a sum not exceeding 3*l.* towards their expenses while attending the College. (*See* §81, p. 30 of the Regulations for Evening Schools, Technical Institutions, and Schools of Art and Art Classes.) Information as to the precise period of these courses is circulated to Science Schools about April.

For any further information required application should be made to the Secretary, Board of Education, South Kensington, London, S.W.

REGULATIONS TO BE OBSERVED BY STUDENTS.

1. All students must enter daily the times of their arrival and departure; books for this purpose are kept in the hall.

2. Students are allowed from 1.15 to 2 p.m. for refreshment, and no student may absent himself for a longer time or during College hours without permission. The Professor, or, in his absence the Demonstrator under whom the applicant is studying, may grant leave for one day, but longer leave will require the sanction of the Board of Education.

3. In case of absence from any cause a communication must AT ONCE be sent to the Registrar. When on account of illness the absence exceeds two days a medical certificate may be required.

4. Smoking in any part of the building is strictly prohibited.

5. Students are required to abstain from shouting, whistling, singing, etc., in any part of the building.

6. Students are required to use the apparatus and specimens with due care, and in case of damage to at once report it to the Demonstrator in charge of the laboratory where it occurs. Damage, through carelessness, will be charged against the person causing it.

7. Both private and State-aided students are required to furnish themselves with certain instruments and apparatus before the commencement of the courses. These are enumerated in the syllabuses of the several subjects.

8. Students who have completed their courses of study must remove all their property (apparatus, books, etc.) from the College, as the Board cannot be responsible for their custody.

9. No student is allowed to remain in the laboratories after hours without express permission in writing from his Professor, which must be shown, on demand, to the Police on duty in the College.

10. The allowances of Royal and Local Exhibitioners will be paid on the first Wednesday of each month at 1 p.m. National Scholars and Teachers-in-Training will be paid four weeks' allowance on the first Wednesday following the opening of the College Session and on every succeeding fourth Wednesday at 1 p.m. Students failing to attend on that day will not be paid till the following month. Change of day, place, or time will in all cases be duly notified.

11. Every student will be required to conform to the rules of the College, to exhibit due diligence in his study throughout the Courses, and to give evidence of satisfactory progress at the different examinations, failing which, or in the event of misconduct, he will not be allowed to remain at the College.

12. Cases of insubordination or wilful disregard of the Rules will be dealt with by suspension from attendance at the College or by expulsion. The Registrar has power to temporarily suspend any offending student until such time as the decision of the Board of Education is made known.

TIME-TABLE.

(N.B.—This time-table is intended as a guide to students in their first and second years; the time-table for the third year is variable and depends on the particular division or branch of study in which the student proposes to take his Associateship.)

First Year.

1ST TERM.

Hour.	Monday.	Tuesday.	Wednesday.*	Thursday.	Friday.	Saturday.*
10 to 11.	Laboratory.	Laboratory.	Laboratory.	Laboratory.	Laboratory.	Drawing.
11 to 12.	Laboratory.	Laboratory.	Laboratory.	Laboratory.	Laboratory.	Drawing.
12 to 1.15	Lecture. Theory and Methods of Chemical Analysis.	Lecture.	Lecture.	Lecture.	Lecture.	Drawing.
		The General Principles of Theoretical and Systematic Chemistry (Part I.).				
2 to ?.	Laboratory.	Laboratory.	—	Laboratory.	Laboratory.	—
3 to 5.	Mathematics. Class A. „ C.	Mathematics. Class B. „ D.	—	Mathematics. Class A. „ C.	Mathematics. Class B. „ D.	—

N.B.—Students who have been released from attendance at instruction in Drawing and Mathematics, are required to carry on their ordinary work in the Laboratory during Laboratory hours.

* The College closes at 1 p.m. on these days.

TIME-TABLE.
First Year.
2ND TERM.

Hour.	Monday.	Tuesday.	Wednesday.*	Thursday.	Friday.	Saturday.*
10 to 11.	Laboratory.	Lecture.	Lecture.	Lecture.	Lecture.	Drawing.
		Physics (Part I.).				
11 to 12	Laboratory.	Laboratory.	Laboratory.	Laboratory.	Laboratory.	Drawing.
12 to 1.15.	Lecture.	Laboratory.	Laboratory.	Laboratory.	Laboratory.	Drawing.
2 to 3.	Laboratory.	Laboratory.	—	Laboratory.	Laboratory.	—
3 to 5.	Mathematics. Class A. „ C.	Mathematics. Class B. „ D.	—	Mathematics. Class A. „ C.	Mathematics. Class B. „ D.	—

N.B.—Students who have been released from attendance at instruction in Drawing and Mathematics, are required to carry on their ordinary work in the Laboratory during Laboratory hours.

* The College closes at 1 p.m. on these days.

TIME-TABLE.

Second Year.

1ST TERM.

Hour.*	Monday.	Tuesday.	Wednesday.*	Thursday.	Friday.	Saturday.*
10 to 11.	Lecture.	Lecture.	Lecture.	Lecture.	Lecture.	Descriptive Geometry or Biological Laboratory.
	A. Elementary Mechanics, Mechanism, and the Steam Engine. B. Morphology and Physiology of leading types of Animal and Vegetable Life.					
	Lecture.	Lecture.	Lecture.	Lecture.	Lecture.	
11 to 1.15.	A. Mechanics Class and Laboratory Work. B. Biological Laboratory.	A. 11 to 12.15 Mechanics. 12.15 to 1.15 Mechanics or Applied Electricity Lecture.† B. Biological Laboratory.	A. Mechanics Class and Laboratory Work. B. Biological Laboratory.	A. Mechanics Class and Laboratory Work. B. Biological Laboratory.	A. Mechanics Class and Laboratory Work. B. Biological Laboratory.	Descriptive Geometry or Biological Laboratory.
2 to 5.	A. 2 to 4 Machine Drawing or 2 to 3 Machine Drawing, 3 to 5 Mathematics or 2 to 5 Applied Electricity Laboratory.† B. 2 to 4 Biological Laboratory.	A. 2 to 4 Machine Drawing or 2 to 3 Machine Drawing, 3 to 5 Mathematics. B. 2 to 4 Biological Laboratory.	—	A. 2 to 4 Machine Drawing or 2 to 3 Machine Drawing, 3 to 5 Mathematics. B. 2 to 4 Biological Laboratory.	A. 2 to 4 Machine Drawing or 2 to 3 Machine Drawing, 3 to 5 Mathematics. B. 2 to 4 Biological Laboratory.	—

N.B.—A. is taken with Descriptive Geometry by Students working for the Associateship in the Divisions of Mechanics, Physics, Chemistry, Metallurgy, or Mining, while B. is taken by those working for the Divisions of Biology or Geology, and for them Descriptive Geometry is an optional subject.

* The College closes at 1 p.m. on these days.

†Applied Electricity is taken by Students working for the Associateship in the Divisions of Mechanics, Physics, Metallurgy or Mining, and is optional for those working for the Associateship in Chemistry.

TIME-TABLE.

Second Year.

2ND TERM.

Hour.	Monday.	Tuesday.	Wednesday.*	Thursday.	Friday.	Saturday.*
10 to 11.	Lecture.	Lecture.	Lecture.	Lecture.	Lecture.	Descriptive Geometry.
	Elementary Geology with Mineralogy.					
11 to 12.	Laboratory.	Laboratory.	Laboratory.	Laboratory.	Laboratory.	Descriptive Geometry.
12 to 1.15.	Laboratory.	Laboratory or Applied Electricity.†	Laboratory.	Laboratory.	Laboratory.	Descriptive Geometry.
2 to 5.	Laboratory or Applied Electricity.†	Laboratory.	—	Laboratory.	Laboratory.	—

* The College closes at 1 p.m. on these days.

Students studying for the Associateship in Physics (as far as space will permit) and Chemistry, work in the laboratories of those Divisions during the afternoons of the Second Term of the Second Year.

† Students working for the Associateship in the Divisions of Mechanics, Physics, Metallurgy or Mining attend at the City and Guilds Central Technical College on Mondays from 2 to 5 for Laboratory Instruction, and on Tuesdays from 12.15 to 1.15 for Lectures in Applied Electricity. Such attendance is optional for students working for the Associateship in Chemistry.

SESSION 1903-4.

SYLLABUS

OF

THE COURSES OF INSTRUCTION.

Mechanics and Mathematics.

Professor.—J. PERRY, M.E., D.Sc., LL.D., F.R.S.
Assistant Professor.—A. R. WILLIS, M.A., D.Sc., A.R.S.M.
Instructors.—P. T. WRIGLEY, M.A.; J. HARRISON, M.I.M.E., Assoc. M.I.C.E.

MECHANICS (including Applied Mechanics and Mechanical Engineering).—PART I.

Lectures, 4l. Laboratory and Classwork, 6l.

The lectures in Mechanics, Part I., will begin on Thursday, October 8th, 1903, and will be given at 10 a.m. each week day, except Saturdays. The class instruction and laboratory work will commence on 8th October, and continue until the middle of February, 1904.

SYLLABUS OF THE LECTURES.

Introductory.—The objects aimed at in giving this course of lectures. Necessary connexion between the lecture room, laboratory, drawing office, workshop, and exercise classes. Hypothetical and practical mechanics, illustrated by the triangle and polygon of forces. The combination of mathematical and experimental methods of working.

Work.—Mechanical energy. A perpetual motion impossible, is the simplest axiom. Potential energy of lifted weights, strained springs, &c. Effect of friction. Use of squared paper. Law of friction in machines. Loss of energy due to friction. Laws of friction between solids, and

between solids and fluids. Friction at journals. Roller bearings. Mechanical advantage. Rate of doing work. Horse-power. Efficiency of a machine.

Velocity ratio.—Blocks and tackle. Inclined plane. Screw. The differential pulley block. Law of moments. The lever. Hydraulic pressing and lifting machinery. Shafts driven by belting. Shapes of wheel teeth. Worm and worm wheel. Skeleton drawings. Simple harmonic motion. Crank and connecting rod. Mechanism in general.

Transmission of power by shafting.—Couplings. Dynamometer coupling. Strengths of belts and how belts transmit power. Friction between belts and pulleys. Absorption dynamometers.

Kinetic energy.—Energy indestructible. Pendulum. Laws of falling bodies. Newton's one law of motion. Energy in a rotating body. Comparison of bodies having motions of translation with bodies having motions of rotation under the action of forces. Energy stored up in fly-wheels. The energy stored up in any moving machine. The steadiness of machines. The function of a fly-wheel. To determine the fly-wheel suitable for a punching, shearing, or riveting machine, for a gas engine or steam engine.

Extension and compression.— How a pull is exerted. How tensile strain is measured. Tensile stress. Elasticity and strength of a tie rod. Compressive strain and stress. Permanent set. Nature of the strain in a tie rod. Modulus of elasticity of bulk. Strengths of pipes and of boilers of various shapes.

Properties of materials. — The knowledge possessed by workmen. The "killing" of copper and iron wire. Effect of a Sunday rest on a twisting and untwisting wire. "Live" and "dead" loads. Strain energy. The tempering of steel. Annealing. Necessity for a knowledge of physics and chemistry in mechanical engineering.

Materials. — Stone. Preservation of stone. Artificial stone. Bricks. Limestone. Mortars. Cement. Manufacture of Portland cement, concrete, &c.

Earth.—The pressure of earth on walls. Foundations of buildings.

Water.—Pressure of water at rest and in motion. Flow of water from orifices. Measurement of water by rectangular

and triangular gauge notches. Professor James Thomson's theory. Turbines and centrifugal pumps.

Timber.—Warping. Seasoning. Preserving.

Glass.—Annealing. Toughened glass.

Cast Iron. Pig iron.—What occurs in the cupola. Patterns and castings. The cooling of castings. Chilled, malleable, and toughened cast iron.

Wrought iron.—Refining, puddling, rolling, &c. Qualities of iron in the market. Case hardening.
Bessemer, Siemens, and Basic steel. Shear and cast steel, Tempering.
Copper, brass, bronze, gun metal, phosphor bronze, &c.

Shear strain.—Nature of shear strain. The stiffness and strength of shafts. Punching and shearing machines. Strengths of riveted joints.

Bending.—Theory of bending. Strength modulus of a section. Strength and stiffness of rectangular beams loaded and supported in various ways. Curvature of a beam at any point. Elastic curve. Testing timber beams. Combined bending and crushing. Conditions of stability of masonry arches and piers. Struts and pillars.

Graphical statics.—Resultants and equilibrants of forces. Forces acting at a point. Force and link polygons. Graphical proofs. Centres of area. Moments of inertia. Diagrams of bending moment. Shape of a loaded beam. Hinged structures loaded. Roof and bridge trusses. Suspension bridges. Arched ribs of masonry. Fuller's rules. Metal arches. Buttresses.

Spiral springs.—Flat spiral springs. Cylindric springs when twisted, and when elongated or compressed; their strength and stiffness.

Periodic Motion.—Simple Harmonic motions. Periodic times of various vibrating bodies. Composition of motions. The balances of watches and vibrating parts of instruments. The stilling of vibrations.

The Effect of a Blow.—Hammers. Pile Drivers. Hydraulic propulsion. Turbine water wheels. Impulse wheels, Ballistic pendulum.

The Balancing of Machines.—Balancing rotating parts. Balancing reciprocating parts.

Applications.—Rapid sketch of the nature of the application of mechanical principles in engineering and machine design.

The Steam Engine.—General construction. Expansion of steam. Condensation of water in the cylinder. Compound and three-cylinder engines. Water per hour per horse-power. The indicator. Valve motions generally. The locomotive slide valve. Lap, lead, and advance calculations. Link motions and radial gears. Arrangements of modern steam engines. Stationary, marine, and locomotive boilers and their fittings. Some steam engine details. Fly wheels, governors, &c. The machines usually driven by steam engines, and the gearing employed. Efficiency. The Lancashire boiler and its fittings. A good furnace. Combustion. Coal. Efficiency of a boiler. Boiler fittings. Modern marine and locomotive boilers. Draught.

The Gas Engine.—History of air and gas engines. Energy of 1 lb. of coal gas. Dowson's gas. The manufacture and composition of gases used for heating purposes. Action of the Otto and other engines. Gas engine diagram. Indicated horse-power and efficiency. The machines usually driven by gas engines and the gearing employed.

In Experimental and Theoretical Mechanics all the subjects included in the syllabuses for the Intermediate and Final Examinations in the Faculties of Science and Engineering for Internal Students of the University of London will be taught in this Course.

Mechanical Laboratory.

List of experiments to be performed by students in illustration of the lectures in Mechanics, Part I.

Quantitative illustrations of the composition and resolution of forces; the principle of moments. Force polygon. Link polygon. Why the illustrations are defective. Quantitative experiments on the effect of friction in various machines. Laws of friction between solids with dry or lubricated surfaces. Friction of fluids independent of pressure. Friction at different speeds. The efficiencies of various lifting machines such as blocks and tackle, differential pulley blocks, hydraulic jack, screw jacks &c. Illustration of the law of the friction between a belt and pulley. Kinetic energy of a rotating body, such as a fly-wheel. Illustrations of the laws of Dynamics by Attwood's machine. Strength of materials. Quantitative experiments on the laws of tensile stress and strain. Shear stress and

strain. Torsion of wires. Strength and stiffness of beams of different sections and materials. Quantitative illustrations of the laws of centrifugal force. Study of valve motions by means of models. Stiffness and resilience of spiral springs. In testing materials simple methods are adopted, and small specimens employed, which can be broken by the application of comparatively small forces, so that the intervention of complicated machines is not necessary.

Measurement of Young's Modulus. Use of extensometer. Determination of the modulus of torsion by Maxwell's apparatus. Finding moments of inertia by bifilar and trifilar suspension apparatus. Experiments with Kater's pendulum. Finding the value of "g" by pendulum observations. Observations on the extension and vibration of springs. Use of the ballistic balance. Direct impact—Elastic and inelastic. Experiments with ball rolling on inclined plane. The measurement of the slope and the deflection of beams, and of the pressures on the supports in the case of a continuous beam. Use of step-by-step dividing machine in the construction of scales and verniers. Use of Cathetometer and optical lever. Experiments on the balancing of rotating bodies.

N.B.—There are certain properties of wood and metals which can only be known through the use of hand tools. Some opportunities of practising with such tools will be given to those students who have not had any workshop practice.

Machine Drawing.—Part I.

Fee 3l. per term.

Practice in the use of instruments by the careful execution of a graduated series of tracings. Qualities constituting a good style of work. The making of hand sketches and the taking of dimensions of simple details of machines. Pencil drawings from these sketches. Tracing, dimensioning, and sectioning the drawings, and the production of photographic prints. Proportional dimensions of details, such as bolts and nuts, rivets, keys, and cotters.

Students will make sets of drawings and tracings from their own measurements, the examples being mainly details of engine and boiler work, mill-work and hydraulic work.

Graphics and Practical Geometry.

Fee 3l. per session.

The following subjects will be dealt with, so far as there is time:—

With what accuracy does a student measure the magnitudes of lengths or angles? Effects of inaccuracy. The number of significant figures given in an answer. Construction of a slide rule. The use of squared paper: (1) In recording such things as the height of the barometer, or the price of a commodity, or statistics, and the information obtainable from a curve. (2) Calculating a table of logarithms. (3) Finding areas, volumes, centres of gravity, and averages. (4) Graphing functions. (5) Finding empirical formulæ. (6) Replacing complex by simple formulæ, approximately correct. (7) Solving equations. (8) Working exercises on maxima and minima. Vectors, addition, subtraction, and the scalar product. Forces. Exercises involving the Link Polygon.

Constructions by Plane Geometry, the Circle, Conic Sections, cycloidal curves. Involute. Evolute. Curvature.

The graphic representation of the forms and relative positions of objects in space, in such a manner that magnitudes can be measured from the drawings. Orthogonal projection. Planes of projection or of reference. Simple examples of projections and sections of polyhedra. Rectangular and polar co-ordinates of a point. Representation of planes, and problems on the straight line and plane Plane and solid figures in given positions. Sections. Developments. Projections of curves and of figures bounded by curved surfaces. The sphere, cone, and cylinder. Metric projection. Interpenetrations. Tangent planes. Surfaces in contact with one another. The principles of perspective projection.

MECHANICS (including Applied Mechanics and Mechanical Engineering).—PARTS II. AND III.

Lectures, Laboratory, and Classwork. Fee 8l. per term.

Part II. will consist of lectures, laboratory and class instruction, beginning on Wednesday, October 7th, 1903, and ending about the middle of February, 1904.

Part III. will commence on February 15th, 1904, and terminate with the sessional examination in June. The following subjects may be dealt with, but, in different years, different parts of the syllabus may be treated much more elaborately than others, and there may not always be time to cover the whole course.

Forces in one Plane.—Properties of the vector and link polygons with examples. Centres of gravity and moments of inertia. Momental ellipse.

Forces in Space.—Reduction of a general system of forces in space to two forces at right angles to one another. Further reduction to a single force along the central axis, and to the minimum couple.

Theory of Structures.—The forces on roof trusses and railway bridges. Wind pressures. Travelling loads. Examples of pin-jointed braced frames of two and of three dimensions in space. Conditions of stiffness and non-redundancy. Force diagrams for such frames. Deflections of braced structures. Diagrams of load intensity, shearing force, bending moment, slope, and deflection for beams loaded transversely and supported in various ways. The scales for measuring the results. Suspension bridges and jointed arches. Structures with redundant members or stiff joints. Application of the principle of work to determine the forces and deflections. The forces in arched ribs, and stiffened suspension bridges. Masonry structures. Conditions of stability. Walls and buttresses. Reservoir embankments. Arches.

Strength of Materials.—The properties of materials used in construction. How they behave in testing machines. Influence of shape of section of test piece. Fatigue. Flow of metal. Initial strains. Tensile and compressive stress and strain shear stress and strain. Thick cylinders.

Bending moment and strength and deflection of beams in general. Beams fixed at the ends. Continuous beams. Shear stress in beams. Deflection due to shear strain in beams. Combined bending and torsion; bending and thrust. Stability of shafts under centrifugal force, bending, thrust and torsion. Struts laterally loaded. The strength of a link such as a connecting rod at any speed of the engine.

Spiral springs. Carriage springs. Springs of any shape subjected to bending.

Application of the mathematical theory of elasticity so far as to vindicate engineers' methods of calculation in shaft and beam problems; thick cylinders; rotating disc; local and surface effects of loading.

Valve Diagrams.—The Zeuner and Reuleaux valve diagrams for a simple slide valve worked by an eccentric, taking account of the shortness of the connecting and eccentric rods. Reversing gears actuating a single valve:—The single movable eccentric, link gears, including the Gooch, Stephenson, Allan and Stewart-Fink gears. Radial gears, including the Hackworth, Marshall, Joy, Morton, and the Waldegg-Walschaert gears.

Expansion Valves.—The Rider valve. Meyer's variable expansion gear. Expansion valves worked by link gears or radial gears. Corliss valves. The determination of the first harmonic in the oscillations of the valves, due to the obliquities of the rod or links.

Plane Motions of Machine Parts.—Diagrams of position, velocity and acceleration. The setting out of wheel teeth. Forms and proportions of teeth, length of addendum, arc of action. Bevel and screw gearing. Centrodes for plane motion. Diagrams of turning effort and resistance on the crank shaft of an engine. Fluctuations of energy and speed of a fly-wheel. Forces due to the linear and angular oscillations of machine parts. Straining actions in coupling rods and connecting rods due to accelerations. Governors for engines; diagrams of speed and range of speed.

Diagrams of twisting, bending, and shearing in crank shafts. Combined bending and twisting.

Dynamics of Machines.—Efficiency of machines. Forces due to accelerations. Effect of a blow. Vibration. The

effect of friction on vibration. The balancing of machinery. Fluctuations in speed. Governors.

Hydraulics.—Fluid motion in general. Orifices and notches. Hydraulic machine tools. Hydraulic presses. Lifts. Pressure engines. Fluid friction. Hydraulic transmission of power. Whirling fluid. Centrifugal pumps, fans, and turbines. Hydraulic propulsion. The change of pressure and velocity along and across stream lines in water and air. The "rotation" in a fluid. Recent investigations on lubrication and friction in pipes.

Heat Engines.—Principles of thermodynamics applied to steam, gas, and oil engines. Fuel. The mechanical, physical, and chemical properties of water-stuff, coal gas, producer gas, and other gases and burning oils. Efficiency of the heating parts of boilers. Forced and chimney draught. Amount of evaporation. What goes on in the cylinder of an engine. Effect of drawing away the water, of exposing surface, of range of temperature, of the conductivity of the metal, of using higher speeds. The usefulness of a steam jacket, and of superheating the steam. Compound and triple expansion. Advanced course on gas engines. The oil engine. Refrigerating machines.

Machine Drawing.—Parts II. and III.

Fee 3*l. per term.*

In this course the students will make working drawings and tracings of portions of built-up structures such as boilers, cranes, roof trusses, railway bridges They will also make working drawings and tracings of valve gears or other portions of engines, of turbines or centrifugal pumps; from measurement or as original designs.

Laboratory Work in Mechanics.—Parts II. and III.

Those parts of the laboratory work in the Part I. Syllabus which have not been worked through by the students will first be taken. There will also be advanced laboratory work in the subjects of Parts II. and III., and endeavours will be made to prosecute original research.

MATHEMATICS.

Fee 3l. per term.

The course of instruction is divided into five classes as follows:—

Class A.—Rapid methods of making approximate numerical calculations. Use of logarithms. Algebra as far as Quadratic Equations with special reference to the simplification of algebraical expressions. Practical uses of squared paper. Finding empirical formulæ from tabulated observations. The elementary parts of plane trigonometry. The solution of triangles. Heights and distances. The simplification of trigonometrical expressions involving the sums and differences of angles. The slope of a curve at a point on it. Meaning of "Rate of Increase" and "Rate of Decrease," and how these are measured. The meaning of the symbols $\frac{dy}{dx}$ and $\int y\,dx$, with simple applications.

Class B.—The graphical representation of simple functions, *e.g.*, x^n, $\sin ax$, e^{ax}. Binomial theorem. Exponential theorem. Logarithmic series. Method of undetermined coefficients. Partial fractions. Summation of series. Interpolation. Elementary properties of determinants. Elementary notions about roots of equations.

Demoivre's theorem. Graphical representation of complex numbers. Exercises on functions of complex numbers. Vector sums and products. Simple examples in vectorial algebra.

The expansion of trigonometrical functions in series.

Elementary parts of plane analytical geometry so far as to include the equations and fundamental properties of the conic sections with simple applications.

Elements of co-ordinate geometry of three dimensions; the equations of a straight line and plane with simple problems thereon.

Elementary notions of the differential and integral calculus. Practical examples illustrating the differentiation and integration of simple functions *e.g.*, x^n., $\sin x$, e^x.

All the subjects included in the syllabuses for the Intermediate and Final Pass Examinations in Mathematics in the Faculty of Science for Internal Students of the University of London will be taught in Class B.

Class C.—The more elementary parts of the Differential and Integral Calculus and of Differential Equations.

Co-ordinate geometry of three dimensions so far as to include the classification and fundamental properties of surfaces of the second order.

Differential Calculus.

Definitions. Differentiation from first principles Differentiation of simple functions and of inverse functions. Geometrical illustrations.—Successive differentiation of functions of one independent variable. Leibnitz's theorem.

Taylor's theorem and Maclaurin's theorem, and their application to simple expansions.

Evaluation of indeterminate forms.

Partial differentiation. Total differentiation of a function of two or more variables.

Differentiation of an implicit function.

Maxima and minima values of functions of one of two independent variables.

Application of the Differential Calculus to the geometry of plane curves, referred to rectangular or polar co-ordinates; tangents, normals, subtangents, subnormals, asymptotes.

Differential co-efficients of arcs, and areas of plane curves.

Convexity, concavity, points of inflexion. Curvature. Radius of curvature referred to rectangular co-ordinates, also to polar co-ordinates. Circle of curvature. Evolutes. Envelopes. Tracing of curves.

Integral Calculus.

Definitions. Elementary integrals. Integration by substitution. Integration by parts. Integration by rationalization. Integration by method of partial fractions. Integration by successive reduction Formulæ of reduction. Elementary definite integrals. Easy application of the Integral Calculus to the quadrature and rectification of curves, and to the determination of the volumes and surfaces of solids, and of moments of inertia.

Differential Equations.

Their nature, origin, and classification. Integrable forms of differential equations of first order and degree. Integrating factors. The methods of integrating differential equations of first order, but not of first degree. Linear differential equations. Integration of them by symbolical methods when the coefficients are constant.

Class D.—The more advanced parts of the Differential and Integral Calculus and of Differential Equations, with special reference to their application in Mechanics

and Natural Philosophy. The course will be varied from year to year, and will include subjects selected from the following:—

General theorems on expansions. Change of variables. Use of symbols of operation. Line, surface, and volume integrals.

Definite integrals. Gamma functions. Elliptic integrals and elementary elliptic functions. Elements of the theory of functions. Applications of conjugate functions.

Elements of the calculus of variations.

Solution of linear differential equations by symbolical methods, by series, and by definite integrals. Simultaneous differential equations. Partial differential equations.

Harmonic analysis, including Fourier's theorem, Bessel functions, spherical and ellipsoidal harmonics.

Elements of the theory of surfaces, including the curvature of lines and surfaces.

Attractions.

Mathematical theory of elasticity.

Class E.—Special courses of applied mathematics, to be varied from year to year, will be given on subjects selected from the following:—

Kinematics.

Dynamical laws and principles.

Vibrations of a system with one or more degrees of freedom.

Applications of generalised co-ordinates in dynamics.

Tops and gyrostats.

Hydrodynamics.

All candidates for the Associateship must qualify in Class A, and they will not be released from attending the mathematical classes until they have so qualified.

In order that Students may be released from attendance when qualified, an examination in the subjects of Class A. will be held on Friday, October 9th, 1903, and also at the end of the first term, in addition to the sessional examination of all the classes in June.

Students proceeding to the Associateship in Mechanics or Physics must further qualify in Classes B and C, and they must continue to attend Mathematics during their third year in Classes D and E, but the granting of the Associateship is not contingent on their having passed in these Classes.

Students are required to provide themselves with the following articles:

Drawing board, imperial size.

T square to suit the drawing board.

One 60° set square, about 10″ long.

One 45° do. do. 6″ do.

A clinograph do. 7″ do.

Two 8-inch boxwood scales, Nos. 1 and 2:

No. 1 Scale:—On one face scales of 1″, $\frac{1}{2}$″, $\frac{1}{4}$″, and $\frac{1}{8}$″, openly divided into 10ths. On the other face two 1″ scales openly divided into 8ths and 12ths; and a centimetre scale closely divided into 10ths and reading from both ends.

No. 2 Scale:—On one face scales of 1″, $\frac{1}{2}$″, $\frac{1}{4}$″, and $\frac{1}{8}$″, openly divided into 8ths. On the other face scales of $\frac{3}{4}$″, $\frac{3}{16}$″, $\frac{1}{3}$″, and $\frac{1}{12}$″, also openly divided into 8ths.

One or two French curves.

Set of drawing instruments, comprising a 6-inch jointed compass, with pen and pencil points and lengthening bar, hair divider, pen and pencil bows, drawing pen, and protractor.

Drawing pencils, H H H, and H H.

Stick of Indian Ink.

Water-colours, nest of saucers, sable brush, and camel's hair brush.

Tracing paper, drawing paper, and drawing pins.

Three quarto note books.

Squared paper.

Book of four figure mathematical tables.

The text books that will be announced in the several courses.

Applied Electricity.

Fee 5l. per session.

A course of instruction in Applied Electricity for Students of the Royal College of Science, consisting of one lecture and three hours laboratory work every week during the session, will be provided in the City and Guilds Central Technical College. This course will be conducted by Professor Ayrton, F.R.S. Attendance is obligatory for Students working for the Associateship in the Divisions of Mechanics, Physics, Metallurgy or Mining, or who are Teachers in Training in the Mechanics Division; it is optional for Students working for the Associateship in the Division of Chemistry, and such Students must inform the Professor of Chemistry at the beginning of the session if they wish to attend this course.

Physics.

Professor.—H. L. CALLENDAR, LL.D., F.R.S.
Assistant Professors.—W. WATSON, D.Sc., F.R.S., A.R.C.S.; A. FOWLER, A.R.C.S., F.R.A.S.

PART I.

Fees: *Lectures*, 5*l*. *Laboratory*, 12*l*.

An elementary course of about 72 lectures, combined with laboratory work on the subjects of the lectures. The lectures will be given by the Professor on Mondays at noon, and Tuesdays, Wednesdays, Thursdays, and Fridays at 10 a.m., beginning on the 15th February, 1904.

Students who enter for the course of lectures on Physics will be examined in Elementary Mechanics. Should their knowledge be insufficient, they will be required to attend a course of about 15 lectures in that subject. These lectures will be given in the afternoons between the end of February and the beginning of March, 1904.

In the lectures on Physics the fundamental phenomena and laws of Physics will be explained and illustrated. A detailed syllabus of the course is given below.

The laboratory will be open from 11 a.m. to 4 p.m. from the 15th February, 1904, until about the 12th of June, 1904.

Students in the laboratory will construct some of the simpler kinds of physical instruments, and will also be instructed in the methods of making measurements of some of the principal physical constants of various bodies with apparatus such as is ordinarily used in a physical laboratory.

The following will be among the constants thus measured:—

(1.) Measurements of length, diameter, and volume, with scale, calipers, gauge, vernier, &c.
(2.) Measurements of thickness and curvature, with the spherometer and optical lever.
(3.) Measurement of weight and mass with the balance.
(4.) Specific gravities of solids and liquids.
(5.) Diameter of and elevation of liquid in capillary tubes.
(6.) Moments of inertia.
(7.) Laws of the simple and compound pendulum.
(8.) Value of 'g' by pendulum methods.
(9.) Young's modulus of elasticity for wires and beams.
(10.) Torsional elasticity.
(11.) Boyle's law.
(12.) Calibration and determination of the fixed points of a mercurial thermometer.

(13.) Coefficients of expansion.
(14.) Specific heats of solids and liquids.
(15.) Latent heat of fusion, and of evaporation.
(16.) Laws of transverse vibrations of strings and rods.
(17.) Pitch of musical notes.
(18.) Longitudinal vibrations of rods and columns of air.
(19.) Velocity of sounds in solids and gases.
(20.) Laws of reflexion and refraction of light by mirrors and lenses. Curvature and focal length.
(21.) Refractive indices.
(22.) Wave-length of monochromatic light by means of Newton's rings and gratings.
(23.) Magnetic moment of a magnet.
(24.) Specific electrical resistance.
(25.) Electromotive force of cells.
(26.) Reduction factor and calibration of a galvanometer.
(27.) Electrolytic measure of a current.

The materials required for the construction of apparatus will be supplied free of charge. The apparatus made will be periodically inspected and considered in the examination, and will be used by the student in making the measurements for which it is designed. It will become the property of the student.

The results of the experiments done during the term, as recorded in the laboratory note-books, will also be considered in the final examination. The laboratory work is essential for all those who propose to become Associates of the Royal College of Science or of the Royal School of Mines, and examinations are held both in the theoretical and practical work. The Physical Laboratory is (under the supervision of the Professor) conducted by the Assistant Professor, Dr. Watson, and the Demonstrators. The written examination in Physics will be held towards the end of June.

Special examinations in laboratory work will be held in the latter half of June. Students in Physics are reminded that no special time can be given to them for preparation for examination. They are expected to keep themselves always prepared for examination in all previously taught subjects in Physics.

For list of apparatus required by Students in the laboratory, *see* pp. 59 and 60.

Syllabus of the Lectures on Physics.—Part I.

General Physics.

Province of Physics.—Conservation of matter and energy. Forms of matter: Solid, liquid and gas. Forms of energy; Molar, molecular, and ætherial.

Units of Measurement.—Fundamental units: Mass, length, and time. C.G.S. system. Derived units: Angle, area, volume, density, velocity. Physical equations and constants.

Graphic Methods.—Use of squared paper. Velocity curve. Acceleration. Vectors. Parallelogram law. Composition and resolution.

Statics.—Forces in equilibrium. Principle of work. Moment or torque. Gravitational units of work and force.

Dynamics.—Laws of motion. Momentum and kinetic energy. Dynamical units of force and work.

Rotation.—Uniform circular motion. Kinetic energy of rotation. Simple harmonic motion. Pendulum.

Law of Gravitation.—Action at a distance. Intensity of field. Flux of force. Potential energy and potential difference.

Stress and Strain.—Hooke's law. Young's modulus. Potential energy of strain. Shearing stress. Rigidity. Limits of elasticity.

Properties of Fluids.—Laws of fluid pressure. Barometer. Work done by fluid pressure. Bramah's press. Indicator diagram.

Elasticity of Volume.—Compressibility of liquids and gases. Boyle's law. Work of Isothermal expansion. Regnault's and Amagat's experiments.

Capillarity.—Capillary pressure. Measurement of surface tension of liquids and films. Work done in stretching a film.

Heat.

Thermometry.—Sensation of heat. Definition of temperature. The mercurial thermometer. Sources of error. Electrical thermometers.

Expansion.—Linear expansion of solids. Relation between linear, superficial and cubical expansion. Methods of measurement. Absolute expansion of mercury. Expansion of water and other liquids. Expansion of gases. Charles' law. The gas thermometer. Absolute zero of temperature.

Calorimetry.—Unit of heat. Specific heat. Calorimeters.

Specific heat of gases at constant pressure. Atomic heat. Variation of specific heat of water.

Nature of Heat.—Transformation of visible energy of motion into heat. Rumford's and Davy's experiments. Experiments of Joule and Rowland. The first law of thermodynamics.

Gases.—Joule's experiments on the internal work of expanding gases. Thomson and Joule's experiments. Calculation of J from observations on gases. Mechanical theory of gases. Van der Waals' formula. Causes of deviation from Boyle's law.

Transference of Heat.—Conduction. Convection. Radiation. Newton's law of cooling. Conductivity and Diffusivity.

Fusion and Solidification.—Melting points. Change of volume by fusion. Effects of pressure on melting points. Regelation. Expansive force of ice. Latent heat of fusion. Bunsen's calorimeter.

Vaporization and Liquefaction.—Boiling points. Volume and pressure of saturated vapours. Non-saturated vapours. Isothermal curves. Critical point. Latent heat of vaporization. Internal and external work. Production of cold by evaporation. Dew point. Hygrometry. Sublimation. The triple point.

Melting and Boiling Points of Solutions, Mixtures, and Alloys.—Cryohydrates. Tension of aqueous vapour over saline solutions. Melting points of alloys. Eutectics.

Wave Motion.

Definitions. Longitudinal, transversal, and compound vibrations. Interference. Reflection and refraction of waves. Water waves.

Sound.

Production of sound by vibration. Transmission of sound. Velocity of sound. Reflection and refraction of sound. Speaking trumpets. Acoustic transparency.

Musical Tones.—Intensity and pitch. The syren. The gamut. Temperament. Interference of sound. Beats.

Resonance.—Analysis of compound notes. Consonant and dissonant intervals.

Modes of Vibration.—Stationary vibrations. Nodes and nodal lines. Transversal vibrations of strings, rods, and plates. Longitudinal vibrations of strings, rods, and columns of air. Organ pipes.

Light.

Propagation of Light.—Rays. Shadows. Images.

Reflection.—Formation of reflected images by plane and curved surfaces

Refraction.—Index of refraction. Lenses. Prisms.

Velocity of Light.—Crucial test of the corpuscular theory.

Intensity of Light.—Law of inverse square. Photometry. Rumford's, Bunsen's, Abney and Festing's photometers.

Dispersion.—Analysis and synthesis of white light. Irrationality of dispersion. Achromatism. Compound colours.

Optical Instruments.—Microscopes and telescopes.

Radiation.—Thermal and chemical effects of radiation. Dark rays. Absorption and emission. Phosphorescence and fluorescence.

Interference.—Newton's rings. Colours of thin plates. Fresnel's interference bands. Diffraction.

Polarization.—Passage of light through tourmaline. Ordinary and extraordinary rays. Nicol's prism. Polarization by reflection. Rotation of the plane of polarization.

ELECTRICITY AND MAGNETISM.

Elementary Magnetic Phenomena.—Natural and artificial magnets. Subdivision of magnets. Magnetic poles. Laws of magnetic attractions and repulsions. Unit pole.

Magnetic Field.—Lines of force. Magnetic induction. Construction of artificial magnets. Methods of measuring the strength of a magnetic field. Magnetic moment.

Terrestrial Magnetism.—Isogonic, isoclinal, and isodynamic lines. Magnetic poles and foci. Secular and diurnal changes in the earth's magnetism.

Elementary Electrical Phenomena.—Electrification by friction. Electrical attractions and repulsions. Insulators and conductors. Electroscopes. Laws of attraction and repulsion. Unit charge.

Electric Field.—Lines of force. Induction. Distribution on conductors. Density. Potential. Capacity. Dielectric constant. Leyden jar. Electrometers.

Electric Discharge.—Electrical machines. Action of points. Forms of spark. Lightning conductors.

Electric Currents.—Electromotive force and resistance. Ohm's law. Practical units. Specific resistance. Fall of potential. Potentiometer. Divided circuits. Wheatstone's bridge. Variation of resistance with temperature.

Thermal Effects.—Joule's law. Peltier effect. Thermo-electric series. Thermopile.

Magnetic Effects.—Magnetic field of a current. Galvanometers. Absolute measurement of current. Forces acting on a circuit in a magnetic field. Work done in moving a circuit. Mutual actions of circuits. Electrodynamometer. Solenoids. Electromagnets. Permeability of iron.

Induction of Currents.—Faraday's and Lenz's laws Eddy currents. Induction coil. Conversion of mechanical into electric energy and *vice versa*.

Chemical Effects.—Galvanic cells. Chemical and electric energy. Electrolysis. Faraday's laws. Voltameters.

Astronomy and Astronomical Physics.

This branch of the course of physics will be conducted (under the supervision of the Professor) by Mr. Fowler, by whom the lectures will also be given.

Due notice will be given of the hours of attendance.

A written examination, which may include questions on the practical work, will be held in June. Credit will also be given for work done during the session.

The following subjects will be dealt with in the elementary lectures:—

Introductory survey of the heavenly bodies.
The celestial sphere and its various circles.
The earth and its rotation.
Revolution of the earth round the sun.
Measurement of time.
Determination of positions.
Measurement of the earth and of the solar system.
The planets, their movements and telescopic appearances.
Kepler's laws.
Gravitation; tides and precession.
The moon; its movements and telescopic appearance.
Eclipses of the sun and moon.
Elements of spectrum analysis.
The sun; its physical features and periodicity. The solar spectrum.
Comets and shooting stars.
The stars; their magnitudes, parallaxes, and proper motions.
Binary, variable, and new stars.
Star clusters and nebulæ.

Practical instruction will be given in the uses of the transit instrument and siderial clock; the equatorial and its accessories; and in some of the simpler methods of determining time, azimuths, and geographical positions. Instruction will also be given in use of globes and Nautical Almanac, and in graphical methods of solving certain astronomical problems.

Physics.—Parts II. and III.

Lectures and Laboratory. Fee 12l. per term.

These courses are designed for students who are in their third year, and who intend to take Physics as their final subject for the Associateship in the Royal College of Science.

Parts II. and III. last from October 7th, 1903, till the middle of June, 1904. During this period courses of lectures will be delivered by the Professor, by Sir William de W. Abney, K.C.B., D.C.L., F.R.S., and by Dr. Watson. A detailed syllabus is given below.

The laboratory instruction in Parts II. and III. will be given, as far as possible, in a separate laboratory. Students will be instructed in advanced thermal, optical, and electrical measurements.

Syllabus of the Lectures on Physics.—Part II.

The lectures will be given on Tuesdays, Wednesdays, and Fridays at noon.

(1.) A course of about 30 lectures will be delivered by the Professor between October and February. The following subjects will, as far as time permits, be discussed:

Thermometry.
Conduction and radiation.
Thermodynamics.
Theory of Gases.
Capillarity.
Viscosity.
Motion of fluids.

The lectures will be arranged to suit the attainments of the class, but a knowledge of the elements of the Differential and Integral Calculus is assumed.

(2.) A course of about eight lectures on light in its connexion with spectrum analysis and colour vision will be delivered by Sir William Abney during January, 1904.

The course will include the following subjects:—

The luminous value of spectrum colours and their combinations, together with a discussion of the instruments used in measurements.

(3.) A course of about 30 lectures will be delivered by Dr. Watson, during the latter half of the session. The following subjects will, as far as time permits, be discussed:—

Absolute electrical measurements.
Periodic Motion.
Sound.
Electrical Oscillations.
Electromagnetic Theory of Light.

(4.) A short course of lectures on Electrolysis and on the Optical Properties of Crystals will be delivered by Mr. S. W. J. Smith, M.A., A.R.C.S.

(5.) A short course of lectures on Magnetic Measurements will be delivered by Mr. R. W. Forsyth, A.R.C.S.

The following are some of the measurements made by Students attending these courses. They are allowed to employ and are instructed in the use of instruments of the greatest sensitiveness and precision :—

1. Methods of testing a balance and of correcting a set of weights.
2. Measurement of length with the cathetometer.
3. Methods of measuring coefficients of viscosity.
4. Density of ice by Bunsen's method.
5. Absolute pitch of notes by the stroboscopic and chronographic methods, and by the siren.
6. Methods of measuring specific heats.
7. Heat of solution of a salt in water.
8. Hygrometry.
9. Vapour densities.
10. Densities of liquids at their boiling points.
11. Coefficients of expansion.
12. Critical temperatures.
13. Conductivity of heat in

14. Lowering of the freezing point of water by dissolved substances.
15. Refractive indices.
16. Wave length of monochromatic light by the diffraction grating.
17. Interference and diffraction fringes.
18. Properties of light polarised by reflection at a glass or metallic surface.
19. Rotation of the plane of polarization.
20. Photometry.
21. Moment of a magnet and strength of a magnetic field.
22. The determination of the magnetic elements.
23. The quadrant and absolute electrometers.
24. Methods of determining the "ratio of the units."
25. Values of electrical standards.
26. Absolute measurements of current and electromotive force.
27. Measurements of high and low resistances.
28. Methods of measuring the resistances of electrolytes.
29. Thermoelectricity.
30. Platinum thermometry.
31. Magnetic permeability.
32. Electrochemical measurements.

Should space permit the Physical Laboratory will be open to those who may desire to prosecute original research with the approval of the Professor, and subject to the special sanction of the Board.

All laboratory students in *all courses* have to provide themselves with the tools and articles in the following list:—

1 hammer.
1 screwdriver.
2 bradawls (assorted).
1 scissors.
1 small plane.
1 small tenon saw.
1 flat file in handle.
2 round files in handles.
2 3-square files in handles.
1 ½-inch chisel.
Small set square.
1 pair flat pliers with cutting edge.
1 pair half-round taper pliers.
1 drill stock.
Assorted metal drills to ¼ inch.
½-lb. strip solder.

Hydrogen.—History, production, and chief properties.

Action of metals on air and water.

Isolation of hydrogen from steam, of nitrogen (and argon) and of oxygen from air by iron, copper, and mercury respectively. Identity of oxygen in water with oxygen derived from air.

Oxygen.—History, production, and chief properties.

Analysis of atmospheric air by various methods, volumetric and gravimetric.

Phenomena of combustion.

Igniting points. Nature of flame. Luminosity of flame. Davy's theory. Evidence of the presence of solid matter in hydrocarbon flames. Frankland's experiments on the influence of pressure. The Bunsen burner.

Composition of water.—Qualitative and quantitative experimentally demonstrated. Physical properties of water.

Chemical properties of water. Impurities contained in natural waters.

Chlorine.—History, manufacture, and properties. Hydrogen chloride, properties and analysis.

Law of Avogadro.—Molecular weights of hydrogen and hydrogen chloride. Determination of atomic weights of elements which form volatile compounds.

Bromine and hydrogen bromide.

Iodine and hydrogen iodide.

Fluorine and hydrogen fluoride. General characters of the halogens. Chemical and thermal relations.

Carbon.—Its allotropic forms. Carbon dioxide. Properties of the gas, liquid and solid. Solution of carbon dioxide in water contains carbonic acid. Carbon monoxide. Effect of moisture on combination of carbon monoxide and oxygen. Compounds of carbon monoxide with metals.

Carbon disulphide.

Marsh gas. Fire damp and explosions in coal pits. The safety lamp. Ethylene. Acetylene. Homologous series of hydrocarbons. Synthesis of carbon compounds by means of the oxides. Organic compounds, improperly so-called. General properties of alcohols, aldehydes, acids, &c.

Sulphur.—Allotropes and action of heat. Sulphur dioxide, sulphurous acid and sulphites. Sulphur trioxide. Sulphuric acid. Modern vitriol plant. Use of Gay Lussac and Glover towers. Sulphates.

Pyrosulphuric acid and pyrosulphates.

Study of the reactions of sulphuric acid with the view of ascertaining its constitution. First ideas of valency and linkage of atoms.

Hydrogen sulphide and disulphide.

Recovery of sulphur from alkali waste by Chance's process.

Thionic acids and other thio-compounds.

Selenion and *tellurium* compared with sulphur.

Periodic classification of the elements.

Phosphorus.—History and manufacture. Allotropic forms. Uses.

Oxides and acids containing phosphorus. Basicity of phosphoric acid. Influence of proportion of oxygen on basicity of acids. Hydrides of phosphorus. Phosphonium compounds.

Phosphorus fluorides, chlorides, bromides, iodides.

Dissociation or thermolysis.

Comparison of sulphur and phosphorus, and of their chief compounds.

Nitrates.—Nitric acid.—Its manufacture, properties, and modes of action.

Nitric anhydride. Nitric peroxide.

Nitrous anhydride. Nitrites.

Nitric oxide. Nitrosyl chloride and aqua regia. Nitrous oxide. Hyponitrites.

Ammonia.—Hydrazine. Hydroxylamine. Azoimide.

Arsenic.—Arsenious oxide and arsenites. Arsenic anhydride and arsenates. Arsine. Marsh's, Fleitmann's and Reinsch's tests for arsenic. Arsenic sulphides, chlorides, bromides, iodides.

Antimony and alloys. Gore's explosive antimony. Oxides of Antimony. Stibine. Antimony chlorides and sulphides. Contrast phosphorus group with nitrogen.

Silicon and Silica.—Silicic acids and silicates. Glass. Silicon fluoride and chloride.

Boron and boric acid. Borax.

Boron hydride, fluoride, chloride.

Comparison of carbon, silicon, boron.

Action of halogens on alkalis and alkaline earths. Bleaching powder and its constitution. Chlorates and chloric acid. Perchlorates and perchloric acid. Iodine pentoxide. Iodic and periodic acids. Peculiarities of iodine; iodonium compounds.

Hydrogen dioxide. Ozone. Argon. Helium.

Review of non-metallic elements.

General properties of metals.—Metalloids.

History and present applications of the words salt, acid, base.

Alkali metals; lithium, sodium, potassium, rubidium, cæsium. Ammonium.

Alkaline earth metals; calcium, strontium, barium.

Zinc group; beryllium, magnesium, zinc, cadmium, mercury.

Aluminium, gallium and indium.

Iron group; iron, manganese, nickel, cobalt, chromium.

Iron and steel manufacture.

Copper. Lead, thallium, bismuth.

Silver. Gold. Platinum group.

Methods of determining equivalents of metals. Considerations leading to atomic weights. Law of Dulong and Petit. Isomorphism. Methods of determining molecular weights.

Solution of solids.—Effect of temperature on solubility. Phenomena of supersaturation. Solution of liquids in liquids.

Solution of gases in liquids. Law of Henry and Dalton. Properties of solutions. Liquid diffusion and dialysis. Osmotic pressure. Gas theory of solution.

Electrolysis and theories connected therewith.

Conditions of chemical action. Influence of mass and of valency. Rate of chemical change.

Students who enter the laboratory course will be examined at the beginning of the term in Chemical Arithmetic; should their knowledge be found insufficient they will be required to attend a class for instruction until they show a satisfactory acquaintance with the subject.

A course of about 12 lectures will be given by Dr. Morgan on the Theory of Analytical and other Processes, qualitative and quantitative, carried on by the students in the laboratories during Part I.

SYLLABUS.

Interaction of the common metals and acids.

Preparation and properties of simple and double inorganic salts.

Qualitative Analysis. Detection of metallic and non-metallic radicles by wet and dry reactions. Reagents commonly employed in analytical work.

Introduction to quantitative analysis. Hints on the simpler gravimetric estimations and the use of standard solutions and indicators.

First year students will be required to attend these Lectures, unless excused by the Professor on the ground of sufficient knowledge. An examination on the Theory of Analysis will be held at the end of the term. All first year students must attend this examination.

INTRODUCTORY COURSE TO PARTS II. AND III.

Students who propose to take their Associateship in Chemistry will substitute Chemistry for Geology in the afternoons during the second term of their second year. They will continue their analytical studies in the Chemical laboratories so far as time permits, and will, in addition, attend a course of about 30 lectures on Elementary Organic Chemistry. These lectures will be preparatory for those on Physical and on Organic Chemistry in the third year, and

will be given by the Assistant Professor on Tuesday and Friday afternoons at 2 p.m. commencing February 16th, 1904.

Organic Chemistry.

Syllabus.

Subject matter and scope of "Organic" Chemistry. Elements which may occur in "organic" compounds. Qualitative recognition of these elements. Proximate and ultimate analysis of Carbon compounds. Empirical and molecular formulæ. Determination of molecular weight. Isomerism. Constitutional formulæ. Hydrocarbons as reference compounds. Homology. Saturated and unsaturated compounds.

Fatty Series.

Hydrocarbons of the paraffin, olefin and acetylene series—Methane, ethane and propane. Petroleum and paraffin. Ethylene and propylene. Acetylene and allylene.

Methyl and ethyl alcohol. Primary, secondary, and tertiary alcohols. Allyl alcohol.

Alkyl chlorides, bromides and iodides. Allyl iodide. Ethylene and ethylidene dichlorides. Chloroform. Carbon tetrachloride.

Methyl and ethyl ethers.

Mercaptan and ethyl sulphide.

Methylamine and ethylamine. Primary, secondary and tertiary amines. Quaternary ammonium compounds.

Phosphines, arsines and cacodyl compounds.

Zinc and mercury ethides.

Cyanogen and the cyanides. Nitriles and isonitriles.

Formaldehyde. Acetaldehyde and its derivatives. Acrylic aldehyde.

Acetone and its derivatives.

Formic acid. Acetic acid and its derivatives. Propionic, butyric, palmitic and stearic acids. Soaps.

Acrylic and oleic acids.

Ethylene and ethylidene glycols. Glyoxal.

Glycolic and lactic acids.

Carbamic acid. Urea. Thiourea.

Oxalic acid. Malonic and succinic acids.

Glycerol. Fats and fatty oils.

Malic, tartaric and citric acids.

Mannitol and dulcitol.

Dextrose, lævulose and galactose. Cane-sugar, milk, sugar and maltose.

Aromatic Series.

Constitution of benzene. Isomerism in the benzene series. Substitution in the benzene series.

Benzene. Toluene and the xylenes. Styrolene. Phenylacetylene.

Chlorobenzenes and chlorotoluenes. Benzyl and benzal chlorides.

Nitrobenzene and its derivatives. Nitrotoluenes.

Aniline and its derivatives. Toluidines.

Diazo-compounds and their transformations. Phenylhydrazine.

Azobenzene and hydrazobenzene.

Benzenesulphonic acid.

Phenol and its derivatives. Cresols. Catechol, resorcinol and quinol. Quinone.

Benzyl alcohol.

Benzaldehyde. Salicylaldehyde. Cinnamic aldehyde. Acetophenone.

Benzonitrile and benzyl cyanide.

Benzoic acid and its derivatives. Toluic and phenylacetic acids. Cinnamic acid.

Salicylic acid. Mandelic acid. Gallic and tannic acids.

Phthalic and terephthalic acids. Mellitic acid.

Naphthalene.

Anthracene and Anthraquinone.

Pyridine and quinoline.

CHEMISTRY.—PART II.

Fee: Lectures and Laboratories, 16*l*.

A course of about 30 lectures on Physical and Theoretical Chemistry will be given by Dr. J. C. Philip on Tuesdays and Fridays, beginning in October, 1903.

SYLLABUS.

The Properties of Matter.

States of aggregation. Gaseous state; ideal laws; compressed gases. Liquid state: liquefaction. Critical condition. Solid state.

Physical Properties and Chemical Nature.

Properties of gases.—Kinetic theory of ideal gas. Avogadro's hypothesis. Vapour-density. Diffusion and effusion. Van der Waals' theory of compressed gases. Specific heat.

Properties of liquids.—Kinetic theory. Molecular complexity. Vapour-pressure and boiling point: experimental methods: criteria of purity.

Density: methods: molecular volume; Schroder's views. Comparable temperatures.

Molecular refraction and dispersion: applications to tautomerism.

Rotation of the plane of polarisation: Guye's Theory. Magnetic Rotation: applications to [illegible]. Surface tension: applications to molecular complexity.

Viscosity. Specific heat. Heat of vaporisation. Van der Waals' theory: reduced equation of condition. Young's work.

Properties of solids.—Kinetic theory. Melting point and density: experimental methods: criteria of purity.

Specific heat.

Crystals: isomorphism: polymorphism: crystalline systems.

Mixtures.

Mixed gases. Mixed liquids: vapour-pressure: fractional distillation: methods.

Mixed solids: melting point: isomorphous mixtures: alloys.

Solutions.

Indifferent solutions.—Osmotic pressure: methods: Van't Hoff's extension of the gaseous laws.

Vapour-pressure: vapour-pressure and osmotic pressure. Boiling-point: methods: determination of molecular weights.

Freezing-point: methods: freezing-point and vapour-pressure: freezing-point and osmotic pressure: determination of molecular weights. Diminution of solubility: methods.

Associated solutions: influence of nature of solvent and dissolved substance.

Electrolytic solutions.—Conductivity: mechanism of electrolysis: work of Faraday, Hittorf and Kohlrausch hypothesis of electrolytic dissociation.

Diffusion.

Comparison of methods of calculating dissociation. Relation of dissociation to the dissociation constant of the solvent.

Comparison of physical and chemical properties of electrolytic and indifferent solutions.

Colloidal solutions.

Law of Mass Action.

Chemical equilibrium in homogeneous and non-homogeneous systems. Reversible reactions. Application to electrolytic solutions. Ostwald's dissociation constant.

Velocity of reaction. Unimolecular and bimolecular reactions.

Transformation of Energy.

Thermochemistry.—Introduction: different thermal constants: methods. Fundamental laws.

Applications of results to chemical problems.

Thermochemistry of electrolytic solutions: neutralization.

Influence of temperature on systems in equilibrium, and on the velocity of reaction.

Explosion and inflammation.

Heat and chemical energy: Berthelot's principle modern views.

Electrochemistry.—Chemical and electrical energy: la[illegible] of conversion. Reversible elements. Potential difference[illegible] in voltaic cells. Nernst's theory: correlation of electro-motiv[illegible] force and osmotic pressure. Theory of production of curren[illegible]

Photochemistry.—Chemical changes influenced by ligh[illegible] Actinometry. Theory of photochemical action.

CHEMISTRY.—PART III.

Fee: Lectures, 3l. Laboratories, 13l.

A course of about 60 lectures on the Chemistry of Carbon Compounds or Organic Chemistry will be given by the Assistant Professor on Mondays, Tuesdays, Thursdays, and Fridays, beginning February 16th, 1904, and ending about the middle of June.

This course will be of an advanced character, and a knowledge of the subject to an extent covered by the preparatory course will be assumed. The lectures will deal with such groups of compounds as the following:—

Paraffinoid hydrocarbons and their derivatives.
Unsaturated acids and their isomerism.
Cyanogen derivatives and their isomerism.
Ketonic acids and diketones.
Uric acid derivatives.
Carbohydrates.
Polymethylenes.
Furfuran, thiophen, pyrrole and allied compounds.
Benzenoid hydrocarbons and their derivatives.
Reduction derivatives of closed-chain compounds.
Azo-dyes. Triphenylmethane and anthraquinone dyes and other colouring matters.
Terpenes and camphors.
Pyridine and quinoline derivatives. Alkaloids.

In addition such subjects as the stereoisomerism of carbon and nitrogen compounds, tautomerism, laws of substitution, fermentation and enzyme actions, relations between chemical constitution and physical properties, &c., will be discussed; the course being varied from time to time to admit of reference to questions more immediately engaging the attention of chemists.

CLASS FOR PHOTOGRAPHIC MANIPULATION.

A course of about twelve lessons in practical photography as adapted to industrial and scientific purposes, will be given by Mr. Chapman Jones, on Fridays, from 2 to 5 p.m beginning February 26th, 1904.

It will include the photography of engravings, diagrams architectural subjects (interiors and exteriors), machinery

apparatus, &c.; printing in silver, platinum and carbon; the preparation of lantern slides for educational purposes, copying tracings, &c.

Each student joining this class must provide himself with a set of apparatus, of which the following may be taken as an example:—

A half plate bellows camera with swing back and rising front, and one or more double backs.
A suitable lens.
A focussing cloth.
A tripod stand.

Students about to purchase are advised to apply for further details of this apparatus.

This class is primarily intended for third year's students. As the accommodation is limited application for admission must be made to the Professor.

Chemical Laboratories.

The laboratories will open on Wednesday, October 7th 1903.

The laboratory hours are from 10 a.m. to 4 p.m., with the exception of Wednesdays and Saturdays, when they are closed at 1 p.m.

The practice of experiment by the student himself, as distinct from the observation of experiments made by the teacher in the lecture room, is indispensable to the acquisition of a real knowledge of chemistry.

The course of study in the laboratories of the Royal College of Science is so arranged (Part I.) that the pupil in the first place learns to verify by his own operations some of the fundamental principles of chemistry, and, in his progress through this course, he is trained to observe accurately and record carefully the results of his experiments. Subsequently each pupil is instructed in the principles of qualitative analysis and in a certain selected series of operations of a quantitative character.

At a later stage (Parts II. and III.) the practical work takes the form of preparing a certain number of pure substances and studying their properties and reactions. This is followed by a complete course of qualitative and quantitative analysis, including the analysis of minerals and various natural or manufactured products both inorganic and organic, gas analysis and the use of physical instruments and methods, such as are employed in modern chemical laboratories.

While the fundamental studies are the same for all pupils, specialisation is encouraged when sufficient

progress has been made, and senior students take part in chemical research.

Each laboratory student works independently. All operations are superintended by the Professor, Assistant Professor, or Demonstrators. A table, with drawers, cupboards, and shelves, is appropriated to every pupil. The College supplies gas, fuel, and reagents. The larger and more expensive instruments of the Laboratory, such as air-pumps, thermometers, barometers, condensers, &c., may be used by the students, who are held responsible for their safety. The students have to provide themselves only with the apparatus specified in the Laboratory regulations. More advanced students engaged in private researches have to supply themselves with such materials as are not included amongst the ordinary reagents of the Laboratory.

A limited number of advanced students who have distinguished themselves in Chemistry are admitted free to the Research Laboratory. Under certain conditions these students will be supplied gratis with chemicals and apparatus.

Course of Study to be Followed by Students.

Chemistry.—Part I.

A course of experiment has been arranged which is intended to serve as a general introduction to practical chemistry. This includes experiments on the preparation and crystallisation of salts, and a series of operations partly qualitative and partly quantitative, by which the student learns to verify the laws of definite combination. This course is modified in the case of students who have already had some experience in a laboratory.

Parts II. and III.

Qualitative Analysis.

Recognition of metallic and non-metallic radicles not already studied, recognition of valencies of metals such as iron, chromium, mercury, tin, etc., distinction of normal and acid salts, and detection of impurities in common materials.

Quantitative Analysis.

Precipitations.—Estimation of Ca, Al, Cr, Zn, Pb, K.

Separations.—K from Na (also indirectly ; Ca from Mg in dolomite).

Fusions.—Complete analysis of glass or felspar. Sulphur in pyrites.

Distillations.—NH_4 in ferrous ammonium sulphate or ammonium alum ; chlorine and mixtures evolving chlorine by Bunsen's process. Hg in cinnabar.

Volumetric Work.—Calibration of measuring vessels. Preparation and titration of standard solutions of acid, alkali, silver, permanganate, dichromate, iodine, thiosulphate, and thiocyanate. Application of these solutions to analysis.

Reductions.—Ferric to ferrous salts, nitrates and nitrites to ammonia, etc.

Gas Volumeter. — Estimations of carbonates, nitrates, nitrites, peroxide of sodium or hydrogen, permanganate, &c.

Electrolytic depositions.—Estimation of copper in brass or bronze.

A selection to be made from the following operations according to the requirements of the student.

Manganese from iron in ferro-manganese or spiegel-eisen.

Copper, nickel, and zinc in German silver.

Estimation of constituents of commercial iron, steel, or copper.

Analysis of ores, such as carnallite, dolomite, apatite, hæmatite, spathic iron, red copper, pyrolusite, iron pyrites, copper pyrites, galena, blende, calamine, mispickel, kupfernickel, smaltine, fahl, chrome iron.

Analysis of Carbon Compounds.

Estimation of C and H in benzoic acid.
" " " cane sugar.
" " " benzene.
" " " oxamide or urea.
" " N in oxamide or urea.
" " " nitrobenzene.
" ", Cl, Br, I, S, P in carbon compounds to be prepared by the student :

Preparation of Carbon Compounds, and study of their re-actions and properties. Tests for the recognition of the common carbon acids and bases.

At least six preparations to be preserved, labelled, and deposited with the Senior Demonstrator. Examples should be usually taken from the following list, to which additions may be made as appear desirable :—

Absolute ethyl alcohol.
Ethyl acetate, benzoate, oxalate, iodide, bromide, chloride.
Calcium or potassium ethyl sulphate.
Ethyl bases.
Ether.
Chloral.
Chloroform.
Aldehyd-ammonia.
Acetates of lead, copper, &c.
Acetyl chloride.
Acetamide.
Acetone.
Formic acid and formates.
Ethylene dibromide.
Glycol.
Glycolic acid.
Oxalic acid and oxalates.
Oxamide.
Methylamine hydrochloride.
Ethyl aceto-acetate.
Chloracetic acid.
Glycocine.
Allyl alcohol.
Urea and cyanuric acid.
Thiourea.
Pure benzene.
Brombenzene.
Potassium benzenesulphonate.
Nitrobenzene.

Aniline and acetanilide.
Metadinitrobenzene.
Phenol.
Ortho- and para- nitrophenol.
Tribromphenol.
Picric acid.
Quinone and hydroquinone.
Benzyl chloride.
Benzaldehyd.
Benzyl alcohol.
Benzoic acid and calcium salt.
Benzophenone.
Benzamide.
Benzonitril.
Chlorbenzene.
Diazoamidobenzene.
Amidoazobenzene.
Phenylhydrazine.
Phenyl diazoimide.
Pyruvic acid and hydrazone.
Glucosazone.
Quinoline.
Triphenylmethane.
Rosaniline.
Phthalic acid and anhydride.
Fluorescein.
Purification of anthracene.
Anthraquinone.
β Naphthalenesulphonic acid.
β Naphthol.
Cymene from turpentine.
Terpin and terpineol.

QUANTITATIVE PHYSICO-CHEMICAL EXPERIMENTS.

Melting points. Boiling points. Vapour densities. Specific heats. Rotatory power. Refractive indices, &c.

GAS ANALYSIS.

Analysis of air, coal gas, flue gases, &c.

Rules to be observed by Students in the Chemical Laboratories.

I. All Students are required to supply themselves with a set of apparatus, consisting of the following articles :—

SET OF APPARATUS USED IN PART I.

Conical brass blow-pipe, with bone mouthpiece.
Platinum wire, 9 inches.
Platinum foil, 2 inches long, 1 inch wide.
Test tube stand, 12 holes and 12 pegs.
Test tubes, 30 of 6 inches by $\frac{3}{4}$ inch.
Test tubes, 12 of 5 inches by $\frac{1}{2}$ inch.
Conical flasks, 2, 8 oz., with wide necks.
Test tube brushes, 2.
Beakers, a set of 5, 4 oz. to 16 oz.
German flasks, 1 each—2 oz., 4 oz. ; 2 each—8 oz., 16 oz.
India-rubber stoppers with 2 holes to fit each of the two largest flasks.
Royal Berlin porcelain crucibles, $1\frac{1}{4}$ inch and $1\frac{1}{2}$ inch.
Best German porcelain evaporating basins, 1 each—$2\frac{1}{4}$ inch, $3\frac{1}{2}$ inch, and 4 inch.
Funnels, 2 of $2\frac{1}{2}$ inch, 1 of 2 inch.
Funnel holder for 2 funnels.
Filtering paper, 1 packet each 7 cm., 9 cm., and 11 cm. diameter.
Two iron tripod stands, 8 inches high, one round, one triangular.
Iron retort stand, 20 inch, with 3 rings and clamp.
Iron gauze, 5 inches square, 2 pieces, with asbestos interwoven.
Sand bath, 5 inch, tin plate.
Watch glasses, 2 inches, 6.
Desiccator.
Glass tubes, soft, $\frac{3}{16}$ to $\frac{1}{4}$ inch, diameter, $\frac{1}{2}$ lb., in lengths of about 2 feet.
Thin glass rods, $\frac{1}{8}$ to $\frac{3}{16}$ inch diameter, $\frac{1}{4}$ lb. in lengths of about 2 feet.
Black caoutchouc tube, $\frac{5}{16}$ inch bore, 4 feet.

Black caoutchouc tube, $\frac{1}{8}$ inch bore, 2 feet.
Corks, 2 doz. assorted.
Triangular file, 5-inch, in handle.
Round file, 5 inch, in handle.
Bunsen's gas burners, two, with regulators for gas and air, with star support and chimney, and rose.
Bowed crucible tongs, brass 7 inch.
Composition mortar, 4 inch.
Cobalt blue glass, 4 pieces, $1\frac{1}{2}$ inches square.
Cork borers, set of three.
Two horn spatulas, 4 inch and 6 inch.
Three test paper rolls, 2 blue litmus.
Silver nitrate solution, 4 oz. of 2% strengtn in a stoppered bottle.
Platinic chloride solution, $\frac{1}{2}$ oz. of 5% strength in a stoppered bottle.
Two dusters.
Deal box to contain the set of apparatus.
Drying cone.
Two pipe triangles.

This set, containing apparatus of approved pattern, can if desired be obtained at the Laboratory.

II. Students engaged in quantitative analysis must supply themselves with two weighing bottles, some clock-glasses (one 4 inches, one $3\frac{1}{2}$ inches, two 3 inches), and a set of weights. A platinum crucible and capsule are also very desirable.

Balances, barometers, thermometers, burettes, and graduated vessels are furnished by the Laboratory. All breakages are to be made good.

III. In special scientific investigations chosen by the students themselves, the substances investigated or the materials employed for obtaining them must be found by the students at their own expense, and also the materials employed in the preparation, purification, and analysis of such substances, when employed in large quantities or chemically pure, such as ether, absolute alcohol, &c., &c.

Raw cheaper materials, such as sodium carbonate, acids, &c. will be supplied by the Laboratory.

IV. All preparations made from materials supplied by the Laboratory become the property of the Laboratory.

V. No experiments of a dangerous character are to be performed without the permission of the Professors or Demonstrators.

VI. When an inflammable liquid, such as alcohol, ether, benzene, or petroleum, is to be heated in a glass vessel, this must be placed in a saucepan. Digestions in which inflammable liquids are used must be carried out with an efficient upright condenser.

VII. Sealed glass tubes are to be heated only in the special ovens provided for the purpose.

VIII. Students are not allowed, without special permission, to handle Winchester Quarts containing strong acids or other corrosive or inflammable liquids.

IX. Students, when boiling corrosive liquids in test tubes or otherwise, are required to take precautions to avoid the possibility of projecting such liquid over other occupants of the laboratory.

X. Women Students working in any of the laboratories must wear dresses of woollen material.

Cotton blouses are not allowed.

XI. Students are not allowed to work in the laboratories except under the supervision of some member of the permanent staff.

Biology.

Professor of Botany.—J. B. FARMER, D.Sc., M.A., F.R.S.
Professor of Zoology.—G. B. HOWES, D.Sc., LL.D., F.R.S.

Fee : Lectures, 5l. *Laboratory, 12l. per term.*

I. The instruction in the division of Biology is arranged in two subdivisions, Botany and Zoology.

There is an Elementary and a Final Course in each subdivision.

II. The Elementary Courses begin on October 7th, 1903, and end about the middle of February, the instruction in Botany and Zoology being given on alternate days.

III. The Final Courses in Botany and in Zoology occupy the entire session, and begin on October 7th, 1903.

IV. The laboratories are open to students on week days from 10 a.m. to 4 p.m., with the exception of Wednesdays and Saturdays, when they are closed at 1 p.m.

V. Students have access to a series of preparations and illustrative figures of the immediate objects of their practical work, more especially in the Preliminary courses, and to a more general collection of specimens and models, illustrative of animal and vegetable morphology and palæontology. In the Final Courses, facilities will be given for obtaining a familiarity with original Monographs and the first-hand literature of the Science as the work proceeds.

VI. The Huxley Laboratory for Biological Research is available to those who may be desirous of pursuing special branches of biological inquiry, subject to arrangement with the Professors of Zoology and Botany, and to the sanction of the Board of Education; and persons engaged on original investigation in either this or the other Laboratories in the Biological Department will be encouraged, at the discretion of the Professors, to give Demonstrations or Lectures upon their work to the advanced students.

Botany.

Elementary Botanical Course.

The Lectures will be given on alternate days at 10 a.m.

i. The general morphology of plants; a comparative survey of the leading subdivisions of the vegetable kingdom.

ii. The principal form of tissues; their evolution and development.

iii. The relation of plant structure to the environment, with especial reference to the facts of symbiosis and parasitism.

iv. The principles of classification, as illustrated especially by the Vascular Cryptogams or some other group of plants.

v. The outlines of Vegetable Physiology; metabolism, transpiration, growth, movement.

vi. Reproduction; sexual and asexual processes. Alternation of generations.

vii. The leading facts of Embryology, as illustrated by the Angiosperms, Gymnosperms, Pteridophyta, and Muscineæ.

viii. An account of certain selected Algæ and Fungi (including Bacteria).

The following types (as far as possible) will be studied in the laboratory:—

Helianthus, Ulmus, Zea, Dracæna, Pinus, Selaginella, Aspidium, Funaria, Pellia, Marchantia, Fucus, Œdogonium, Spirogyra, Vaucheria, Agaricus, Eurotium, Mucor, Physcia, Saccharomyces, Bacillus.

In the course of the practical work each student will have the opportunity of preparing for himself a set of permanent specimens illustrative of the structure of the above-mentioned types.

Students will also themselves perform elementary experiments illustrative of the principles of Vegetable Physiology.

Final Botanical Course.

The practical work will include—

i. A detailed examination of representative members of the groups and principal orders of Phanerogams and Cryptogams, together with the more important Fossil forms.

ii. A course of Comparative Anatomy and Histology.

iii. A short course of Practical Physiology.

A general course of Advanced Lectures will be delivered during the year, together with such Special Courses as may from time to time be desirable.

Field excursions will be undertaken during the session as circumstances may permit.

Zoology.

ELEMENTARY ZOOLOGICAL COURSE.

The Lectures will be given on alternate days at 10 a.m.

i. The rise, scope, and progress of Biology.

ii. The principles of Anatomy, based upon the study of the Mammalian organism.

iii. Comparative survey of the broader principles of Histology and Histogenesis.

The nucleus and nuclear division, and concomitant activities.

iv. The leading facts of Animal Physiology.

v. The Elements of Development. The leading types of Segmentation of the egg. The Gastrula and Gastrula Formation. The Embryonic Layers: their formation and their ultimate derivatives.

vi. The principles of Classification, as illustrated by the analysis of a selected order of animals.

vii. The leading morphological characters of the chief Classes of Vertebrates and Invertebrates, and certain of the more salient modifications met with in each, with especial reference to facts of structure having direct bearings on Palæontology.

viii. The first principles of Palæontology, illustrated by certain selected specimens, and more especially by the study of a chosen group. The bearing of the facts upon Phylogeny and Geographical Distribution.

ix. Atavism, Commensalism, Isomorphism and Convergence, Parasitism, Symbiosis, Dimorphism, Polymorphism, Metagenesis, Neomorphism.

In relation to §§ vii. and viii., the following or other fossil forms will be considered as time and circumstances may permit:—*the Anomodontia, Archæopteryx, the Odontornithes, Palæospondylus, Triarthrus.*

The following animal forms will be worked over in full (laboratory work):—*Lepus, Allolobophora* or *Lumbricus, Astacus, Paludina* or *Helix, Mya* or *Anodon, Hydra, Paramœcium, Vorticella, Amœba.* Other Protozoa as circumstances may permit.

The Trochophore and Nauplius Larvæ; the Gastrula and early stages in its progressive development; the development of the Vertebrate and Molluscan Nervous Systems, and of the Higher Sense Organs, and other parts of the Vertebrate body.

In the course of the practical work, each student will be provided with a representative set of permanent elementary histological preparations, mounted and in part prepared by himself.

Final Zoological Course.

The practical work in this course, so far as time and circumstances permit, will include detailed examination of representative members of the great sub-classes and orders of Vertebrates and Invertebrates, and the study of leading facts in Palæontology, Comparative Embryology and Organogenesis, together with Advanced Technology.

Special courses of lectures or demonstrations, variable from year to year, will be given, dealing thoroughly with such branches of the subject as it may be most desirable to select.

For further particulars, *see* Sects. III. to VI.

Students will be required to provide themselves with the following articles :—

1. Box containing :—
   - *a.* Four scalpels.
   - *b.* Large and small pairs of scissors, *with pointed blades.*
   - *c.* Large and small pairs of forceps, *with straight blades.*
   - *d.* Two razors.
   - *e.* German silver blowpipe.
   - *f.* Seeker, *with tapering point.*
   - *g.* Pair of bone forceps, *with excentric hinge.*

2.
   - One dozen glass slips.
   - ½ ounce thin square cover glasses ⅞ in.
   - Three watch glasses.
   - Dipping rod and pipette.
   - Four camel's hair brushes.
   - Sewing needles, various sizes, mounted in brush handles.

3. A Watchmaker's Glass.

4. Small quarto Note Book of white *unlined* paper of good quality.

5. Three or four Coloured Pencils (*not chalks*) and a small box of moist Water Colours.

6. Black lead Pencils (HB and H).

No. 1 may be obtained from the following makers at the prices stated :—

		£	s.	d.
J. Weiss and Son, 287, Oxford Street, W.	*a.* With plain bone forceps and deal box	1	18	6
	b. With best bone forceps and mahogany box	2	3	0
T. P. Hawksley, 300, Oxford Street, W		1	8	4
C. Baker, 244, High Holborn, W.C.		1	5	0
J. Swift, 43, University Street, W.C.		1	6	0
Medical Supply Association, 96, High Holborn, W.C., and 12, Teviot Place, Edinburgh		1	2	0

Geology (including Mineralogy).

Professor.—J. W. JUDD, C.B., LL.D., F.R.S.
Assistant Professor.—C. G. CULLIS, D.Sc., F.G.S.

The Instruction in Geology is arranged in three courses as follows:—

PART I., which begins on February 15th, 1904, comprises elementary instruction in Mineralogy and the various branches of Geology.

PART II. is devoted to Advanced Mineralogy and Petrology with further instruction in the Work of Geological Surveying.

PART III. deals with Stratigraphical Geology and Invertebrate Palæontology.

PARTS II. and III. commence on October 7th, 1903.

GEOLOGY.—PART I.

Fee: *Lectures*, 4*l*. *Laboratory*, 8*l*.

The Lectures and Laboratory Instruction are carried on in conjunction with one another; each day's work in the laboratory embodying, so far as is possible, a series of illustrations of the principles enunciated in the lecture of that day. In the same way the demonstrations in the field are preceded and followed by lectures, in which the structure of the district visited is described. The subjects thus taught in the lecture room, the laboratory, and the field are as follows, though the order in which they are taken up may vary in different years.

Mineralogy and Physiographic Geology.—The art of observing and accurately recording the distinctive characters of Minerals and Rocks—such as colour, lustre, fracture, cleavage, hardness, &c. The use of the most simple and rapid contrivances for determining the specific gravities of rocks and minerals, and the method of isolating the constituents of rocks according to their density, magnetical properties, or chemical nature are also taught, as well as the principles and practice of systematic blowpipe-analysis, with the use of other simple chemical tests.

The great surface features of the Earth's crust are described in the lectures, and especially the distribution of temperature and pressure in the solid crust, the ocean and the atmosphere respectively, with the methods by which observations on these subjects are made.

Dynamical Geology.—The proofs of the interaction of the gaseous, liquid and solid portions of the Earth's crust upon one another are considered; and the forces operating upon that crust, both from within and without, are studied. The results produced by these forces in modifying the forms of the Earth's surface, and in altering the character and distribution of its materials engage special attention.

The Elements of Crystallography.—An account of the chief forms assumed by crystals and their relations to one another; with a discussion of the combinations of forms that occur most frequently among minerals. This part of the subject is illustrated in the laboratory by the students making drawings from models representing the crystals found in all the commonly-occurring mineral species.

Mineralogy.—The physical and chemical principles involved in the study and classification of minerals with descriptions and laboratory-work on the macroscopic and microscopic characters of those species which commonly occur as constituents of rocks. The means of determining the minerals that most frequently occur as ores of the useful metals are also taught.

Petrology.—The nature, composition, and mode of origin of aqueous, igneous, and metamorphic rocks. In connexion with this subject, the deposits—both organic and inorganic—which are being formed upon the ocean-bed at the present time are studied, and the methods of preparing mineral substances for microscopic study, especially the cutting of thin transparent sections are taught to the students. The examination of such sections is carried as far as is possible by the aid of an ordinary petrographical microscope, without the use of special accessory optical appliances. In all cases the study of hand-specimens and microscopic sections of rocks proceeds side by side.

Geognosy.—The study of the positions and relations of the rock-masses forming the Earth's crust, together with the investigation of the changes in composition and structure which result from the action of various forces operating during long periods of time. The nature and mode of formation of fossils and the characters of the chief plants and animals, whose remains are found embedded in the rocks, are also illustrated.

Stratigraphical Geology.—The discussion of the principles on which the chronological classification of rock-masses is based, with an outline of the succession of formations (especially as developed within the British Islands) with their characteristic fossils. Type series of fossils stratigraphically arranged are provided for the use of the students.

Geological Surveying.—The methods to be pursued in making geological maps and sections of all kinds under different conditions are considered; and the subject is illustrated by examples of the maps and sections published by the different geological surveys of Europe and of other parts of the globe. Demonstrations of the methods of constructing sections and maps are given, both in the field and in the laboratory. The question of the practicability of adopting uniform schemes, for colouring and shading geological maps and sections, based on the recommendation of International Congresses, is also considered.

Determinative Mineralogy.—Students taking their Associateship in the School of Mines division of the College (Mining and Metallurgy), go through a somewhat different course of instruction to that given to the other classes of students. To meet their special requirements, a course of instruction in Determinative Mineralogy is provided, consisting of demonstrations on the Nature and Mode of occurrence of the Ores of the Useful Metals, and on the minerals usually found associated with them. An account is also given of all minerals of economic value, and of the conditions under which they are found. Practical work in the laboratory is arranged to illustrate this subject.

Students passing out in the Chemical, Physical, and Mechanical divisions of the College are excused attendance in the Geological laboratories during the afternoons, and are required, instead, to go through special courses of instruction in connection with the subjects in which they propose to take their Associateship.

Students attending the course of Elementary Geology will be required to provide themselves with the following articles :—

A geological hammer.
A pocket magnifying glass.
A blowpipe.
Six inches of platinum wire.
A case of mathematical instruments, with English and metric scales.
A box of water-colours with brushes.
A lecture note-book.
A pocket note-book for use in the field.
A quarto note-book for use in the Laboratory.

Students taking their Associateship in the divisions of Mining and Metallurgy are recommended to provide themselves with blowpipe equipments (including agate mortar, platinum forceps, magnet, streak-plate, &c.) They will also find it to be of great advantage to gradually bring together for reference at home small specimens of the minerals dealt with in the course of Determinative Mineralogy, and in this way to form the nucleus of a private mineral collection. Students must provide their own glass-tubing and charcoal blocks for blowpipe work.

(Before purchasing some of the foregoing articles students are recommended to seek the advice of one of the Demonstrators in the Geological Laboratory.)

Geology.—Part II.

Fee: *Lectures and Laboratory*, 8*l*.

This part and the following part commence on October 7th, 1903, and form an advanced course designed for those students who desire to pass out from the school as Associates in Geology.

Geological Surveying.—Work is carried on in the field illustrating the methods of making geological maps, the instruction being carried farther than is possible in the Elementary Course.

Goniometric Measurement of the Optical Properties of the Rock-Forming Minerals.—A course of lectures on these subjects with practical instruction in the laboratory, under the Demonstrators.

Advanced Petrology.—The methods of making rock-sections under difficult conditions, together with the processes for isolating the minerals of rocks (so as to prepare them for chemical analysis), of identifying minerals and rocks by the use of special optical appliances and by microchemical methods are practised in the laboratory. Lectures are given on the classification and determination of rocks, and this part of the subject is illustrated by the study of a large and carefully selected series of typical rocks from all parts of the globe, and of sections cut from them for examination with the microscope.

Geology.—Part III.

Fee : Lectures and Laboratory, 8l.

Stratigraphical Geology.—The more complete study of the series of sedimentary formations, of their fossils, and of the igneous rocks associated with the several strata, than was possible in the Elementary Course. At this stage the attention of the students is especially directed to the principal foreign representatives of the series of British Strata, and one or more limited groups may be set as a subject for special study.

Invertebrate Palæontology.—The chief fossil forms of the Invertebrata are studied systematically, so far as time will permit, comparisons being made with recent types. For this purpose a carefully selected series of specimens arranged zoologically and illustrated by sections and other preparations are available for the use of the students. Particular attention is directed to the microscopic structures of the shells or other skeletal remains of the organisms, and to the mineral changes that they sometimes undergo. In some cases a small group of organisms is selected for more detailed study. Especial attention is directed to the methods of isolating, mounting, and making thin sections of fossil organisms.

Honours Courses and Research Work.—Students who have completed the whole course of instruction in Geology, and have obtained the sanction of the Board of Education, are encouraged and assisted to undertake the work of original research, in connection with some branch of geological inquiry for which they show special aptitude.

The Lectures are given every week day except Saturday, and begin at 10 a.m. The laboratory instruction, which is given from 11 a.m. to 1 p.m. every day of the week, and from 2 till 4 p.m. on Mondays, Tuesdays, Thursdays, and Fridays, is carried on under the superintendence of the Professor, the Assistant Professor, the Demonstrators, and Student Assistants.

Metallurgy.

Professor.—W. GOWLAND, A.R.S.M.

Instructor in Assaying.—W. H. MERRETT, A.R.S.M.

Fee : Lectures, 2l. per Term. Laboratory, 13l. per Term.

The Course will begin on the 7th October, 1903.

The instruction in this division comprises Metallurgy and Assaying.

METALLURGY is taught by means of lectures, which are illustrated as far as is practicable by means of a small metallurgical plant, and this is supplemented by visits to works in metallurgical districts.

ASSAYING is taught in the laboratory and by means of lectures.

The instruction is arranged in three courses :—

Part I. necessary for Mining Students.

Parts I. and II. for Metallurgical Students working for the Associateship.

Part III. consists of more advanced work suitable for students who have taken the Associateship, and intend to enter for the Honours Associateship.

METALLURGY.—PART I.

This course begins in October and finishes about the middle of February; the instruction in Metallurgy and Assaying in this course is of an elementary character adapted as far as possible to meet the requirements of students who intend to take the Associateship in Mining.

The syllabus of the Metallurgical lectures in Part I. is as follows :

I. General discussion of the nature and objects of metallurgical processes. Limitations imposed by the question of cost.

II. Chief physical properties of metals and alloys.

III. Refractory materials used in the manufacture of firebricks, crucibles, and retorts, and for lining furnaces.

IV. General properties of slags and fluxes. Approximate composition and chief characters of ordinary slags. Means by which some of these are utilised.

V. Classification of furnaces. Modes of producing and utilising heat in the chief types of each class of furnace. Elements of furnace-buildings.

VI. Fuel. Its calorific power and intensity. Experimental methods by which these may be determined. Pyrometry. Calorimetry. Various modes of using fuel. Coal; characters, composition and uses of the various kinds. Charcoal burning. Coke; properties, uses and approximate composition. Coke ovens, and the methods of preparing coke.

VII. Classification of the metallurgical processes for the extraction of metals from their ores by both "wet" and "dry" methods.

VIII. Outlines of the metallurgy of gold, silver, lead, mercury and copper. Their chief ores; the methods of extracting the metals from these ores and of adapting them for use. Their physical properties, and the composition and uses of their principal alloys.

The Metallurgical Laboratories are conducted by the Instructor in Assaying under the direction of the Professor.

During Part I. the course of practical instruction in Assaying is as follows:—

I. The assay by "dry" methods of ores of gold, silver, and lead, and of gold and silver bullion.

II. The volumetric assay of ores of iron, zinc, and copper, and of alloys of copper.

III. The determination of gold, silver, and free cyanide in the solutions obtained in the cyanide treatment of gold ores.

IV. The examination of coal as regards calorific power sulphur, moisture, ash, and coke.

V. The examination of refractory materials as regards their power of resisting high temperatures, and the action of corrosive metallic oxides.

During Part I. one or more metallurgical operations are carried out by means of the small metallurgical plant, one of these being the extraction of gold from its ores in the stamp battery. A number of the students prepare the ores, make the necessary assays and carry out the operations under the direction of a Demonstrator, and all the students are required to observe and note all the stages of the operation.

At the end of the course all the students are examined in the theory of metallurgy and assaying, and their ability to make accurate assays of simple ores and alloys is tested.

In the examination marks are awarded for the work done during the term.

Metallurgical students will be required, during the first term, to attend a short course of lectures and pass an examination in the Principles of Dressing Minerals.

Metallurgy.—Part II.

This course begins about the middle of February and finishes about the end of June. It is intended for students who have already taken Part I., but occasional students wishing to learn special branches of assaying can be admitted to the laboratories at the discretion of the Professor.

The course includes more advanced instruction in metallurgy and assaying, the scope of the course in both the lectures and the laboratory practice being sufficiently wide to meet the requirements of most metallurgical students.

The syllabus of the metallurgical lectures in Part II. is as follows:—

I. The metallurgy, properties, and chief alloys of zinc, tin, nickel, cobalt, manganese, arsenic, antimony, bismuth, aluminium, and the metals of the platinum group.

II. The smelting and manufacture of iron in its various forms of cast iron, wrought iron, and steel. A considerable part of the course is devoted to this branch of the subject.

III. General principles to be followed in setting up a metallurgical works. Details of furnace building, lining and fettling. Chimney stacks. Blowing engines and machines.

IV. Further details of the metallurgy of gold, silver, lead, and copper. Principles to be followed in selecting a process for the treatment of simple and complex ores of these and other metals.

V. Recent work on the constitution of metals and alloys. Pyrometric and micrographic examination of metals and alloys.

VI. Sketch of the relations existing between capital and labour with reference to the various methods of remunerating work-people in metallurgical industries.

In these lectures the conditions to be dealt with in the extraction of each metal are specially considered, and the more important metallurgical appliances fully described.

The object of the lectures is the communication of such instruction as the student may be able to apply to the greatest practical advantage, when subsequently engaged in conducting any metallurgical process.

A class will be held for special instruction in the preparation of working drawings of furnaces, and demonstrations will be given at which the students will lay out, in actual working size, the brick-work of the furnace they have drawn.

A short course of lectures on electro-metallurgy is given by the Instructor in Assaying, who also gives a few lectures in connection with the use of the metallurgical plant, and as a preparation for the visits to metallurgical works.

The syllabus of the course of instruction in Assaying in Part II. includes:—Dry assays of ores of tin and mercury. Dry and volumetric Assays of gold and silver bullion. Volumetric assays of ores of zinc and lead. Assays of ores of chromium and manganese. Assays of the more difficult ores of the metals enumeratcd in the Part I. syllabus. Iron and steel analysis. Analysis of slags, bricks, and refractory materials. Analysis of copper and of spelter. Analysis of alloys. Electrolytic determination of copper, nickel, zinc, and other metals in ores and alloys.

A certain amount of specialisation is allowed in this course, but it is desirable that students should attain to a fair proficiency in most of the branches enumerated above.

Certain practical operations are carried on in a special laboratory provided with furnaces* and other appliances for

* The blast and reverberatory furnaces and the chlorination plant are in the open air, near the laboratory.

illustrating the metallurgical lectures, and for enabling sufficiently qualified students to carry out researches on metallurgical processes.

The scale of the appliances has been kept small, but they are sufficient for purposes of demonstration, and it is therefore possible in some cases to allow students themselves to conduct operations more or less independently.

Demonstrations in Illustration of the Lectures.

During the session a number of these are arranged; the preparation of the ore, the assays of the ore and products, and, when possible, the manipulation of the apparatus being carried out by a selected party of students under the direction of a Demonstrator. By dividing the students up into parties it is possible to arrange during the course demonstrations illustrating certain of the more important metallurgical processes, without interfering too much with the time that each student should devote to assaying.

Each student is expected to spend not less than a fortnight, during Part II., in assisting at these demonstrations, and to prepare notes not only of the work done by himself, but of all the demonstrations made during the course.

Marks are awarded, in the examination, for these notes as well as for the work individually performed.

Among the metallurgical operations for which provision has already been made, the following may be mentioned:—

I. The treatment of gold ores by amalgamation in the stamp battery, and by the chlorination and cyanide processes.

II. The treatment of silver ores by pan amalgamation.

III. The calcination, in a reverberatory furnace, of a sulphide copper or lead ore, and the calcination and chloridising roasting of a gold ore.

IV. The smelting of ores in a small blast furnace.

V. The extraction of copper and other metals from their ores by leaching, followed by chemical or electrolytic precipitation of the metal.

VI. Electrical reduction of metals from their ores, and the electrolytic refining of copper.

Visits to Works.

The students taking Part II. are conducted by the Professor through a number of metallurgical works in Wales or the north of England, permission to visit these works having, in previous years, being courteously given by the owners.

The visits will probably be made in the month of May, during a tour which occupies about a fortnight.

Permission has hitherto also been obtained for the students to visit the Royal Mint, and one or two other manufacturing or testing works in London.

Metallurgy.—Part III.

This is an Honours course intended for students who have taken a First Class Associateship in Metallurgy, but other students of proved ability will be admitted at the discretion of the Professor.

The subjects included in this course may be divided into three groups :—

I. Practical Metallurgy, including:—

Work with a view to acquire familiarity with ordinary metallurgical operations. Ore testing, to determine the most suitable methods of treating particular ores. Experiments with a view to test new or improved methods of extracting metals from their ores.

The above can be carried out in the Metallurgical laboratory during the session, provided they do not interfere with the use of the appliances for the purpose of demonstration.

II. Physical Metallurgy and Research.

Under this head is placed the use of special instruments of metallurgical research.

(1) *Pyrometry.* The research form of the late Sir William Roberts-Austen's recording pyrometer has been installed for the purpose of instruction and for use in metallurgical research. A few other pyrometers are also available.

(2) *Photomicrography* as applied to metals and alloys.

A special room is fitted up for Pyrometry and also one for Photomicrography.

(3) *Calorimetry.* A Berthollet calorimeter, manufactured by Golaz, Paris, and other calorimeters are available for instruction or research.

(4) *Determination of the physical constants,* such as specific gravity, electrical conductivity, and other properties of metals and alloys.

(5) *Mechanical testing of metals.* A testing machine has been provided, and, by its aid, the ultimate tenacity, resistance to crushing and deflection of bars of moderate section may be determined.

(6) *Use of electric furnace.* Furnaces of several types suitable for research can readily be set up and used in the practical metallurgical laboratory. The electrical installation can furnish direct currents of 80 ampères at 60 volts, and larger currents at smaller voltages.

III. Chemical Metallurgical Research.

This includes chemical investigations by analytical and assay methods; chemical research into the nature of alloys or other materials, and chemical investigations bearing on metallurgical processes.

The accommodation for physical and chemical research is at present somewhat limited, especially during Part I.

Students intending to take Part III. Metallurgy should first communicate with the Professor, stating which branch they wish to take up, to ascertain whether the apparatus will be at liberty, and in order that provision may be made for their work.

Students attending Parts I. and II. are required to provide themselves with a set of gramme weights and with apparatus, the cost of which is about two pounds, as specified in the following list:—

1 small hammer.
1 blowpipe.
1 steel spatula.
1 bone spatula.
1 camel hair brush.
2 hard tooth brushes.
2 sheets of glazed paper.

1 pair of small assay shears.
1 pair of scissors.
1 pair of pliers, half round, taper.
1 pair brass forceps.
1 triangular file.
1 8-in. flat file (smooth hand).
1 wire triangle, covered.
1 tripod stand and wire gauze.
1 Bunsen burner with 3 feet of rubber tubing.
Glass rods and tubes, assorted.
2 glass funnels, 3 inches diameter.
4 beakers, Nos. 5, 6, 7, and 8.
1 washing bottle, fitted.
6 conical flasks and small funnels.
6 test tubes.
3 Bohemian flasks, 24 ozs.
1 Berlin evaporating dish, No. 7.
1 do. No. 2, 3½ inches diameter.
1 pair watch glasses and clip.
1 porcelain mortar.
2 porcelain crucibles, 1½ inches diameter.
1 packet of filters, 5½ inches diameter, or filtering paper.
1 lens.
1 duster and 1 cloth.
2 note books (one quarto and one for rough notes).

Balances, rough weights, thermometers, burettes, and graduated vessels are furnished by the Laboratory. All breakages and losses are to be made good.

Principles of Mining.

Professor.—C. LE NEVE FOSTER, D.Sc., B.A., F.R.S., A.R.S.M.

Instructor in Mine-Surveying.—L. H. COOKE, A.R.S.M., F.G.S.

Fee: Lectures and Laboratories { *First term*, 15*l.* / *Second term*, 14*l.*

The Mining Course embraces theoretical and practical instruction in Mining, Mine-Surveying, Metallurgy and Assaying. The lectures on Mining will commence at 10 a.m. on Wednesday, 7th October, 1903. Students are required to attend the lectures on Metallurgy and the Assaying Class from October to February.

The purpose of the lectures on the Art of Mining is to impress on students the principles which should form the basis of the various operations of the miner, and to make them acquainted with examples of mining practice, as conducted under different circumstances in this and other countries.

The course of lectures will be based upon the following syllabus, but will not necessarily include every item named in it:—

I. Occurrence.

The earth's crust. Stratified and unstratified rocks. Lamination or bedding. Thinning out. Principal varieties of stratified rocks. Dip and strike. Bends. Folds. Contortions. Jointing. Unconformability. Veins. Rich parts of veins. Masses. Faults of various kinds. Measurement of their throw. Rules for searching for a vein or seam beyond a fault or dislocation.

Examples of mineral deposits.—Alumstone, amber, antimony ore, arsenical ores, asbestos, asphalt, barytes, bauxite borax, boric acid, carbonic acid, chromite, clay, coal, cobalt ore, copper ore, corundum, diamond and other gems, flint, freestone, gold ore, granite, graphite, gypsum, iron ore, iron pyrites, lead ore, limestone, manganese ore, mica, natural gas, nickel ore, nitrate of soda, oilshale, ozokerite, petroleum, phosphate of lime, potassium salts, quicksilver ore, salt, sand, sandstone, silver ore, slate, sulphur, tin ore, zinc ore.

II. Prospecting.

Aid afforded by geology; evidence given by fossils. Associated minerals. Surface indications: (*a*) form of the ground; (*b*) mineral exposed in natural or artificial

cuttings; (*c*) loose fragments lying about on the surface; (*d*) pieces thrown out by burrowing animals; (*e*) ordinary springs, mineral springs, gaseous emanations, warmth; (*f*) colour; (*g*) decomposed outcrop, gossan; (*h*) indicative plants and animals; (*i*) altered vegetation; (*j*) old workings, slag heaps, ruins, names of places; old records.

Methods of seeking or discovering deposits: (*a*) shoading and loaming; (*b*) probing; (*c*) boring; (*d*) trenching; (*e*) hushing; (*f*) sinking small shafts and drifting; (*g*) dipping needle. Difficulties which beset the prospector. Qualifications of the prospector.

III. Boring.

Uses of boreholes. Boring by various methods. Percussive boring by rods and by rope. Rotatory boring with diamond and steel crowns. Tubing boreholes. Accidents to tools. Cores; methods of cutting them and extracting them. Deviations of boreholes; methods of ascertaining these deviations.

IV. Excavation.

(1.) Tools and Appliances for Excavating by Manual Labour.—Picks and shovels of various kinds. Tools for boring holes by rotation and by percussion. Wedges, simple and multiple.

Explosives and blasting. Classification of explosives Charging shot holes. Methods of firing: Squibs, safety-fuse, electric fuse, and other fuses. Miss-fires. Blown-out shots.

(2.) Machines used for Excavating.—Transmission of power from the surface into underground workings by water, compressed air and electricity. Advantages and disadvantages of each of the three systems.

Excavating machines:—

(*a*) Diggers and dredgers; (*b*) Percussive and rotatory rock drills; (*c*) groove-cutting machines of various types, viz.: mechanical chisels, circular saws or disc-machines, endless chains, revolving bars, wire-saw; (*d*) tunnelling machines; (*e*) shaft-sinking machines.

Amount of work done by machines compared with hand labour. Advantages and disadvantages of each type of machine.

(3.) Special Methods of Excavation —Excavation: (*a*) by heat or fire-setting and steaming; (*b*) by solution; (*c*) by jet of water (hydraulic mining).

(4.) Excavating Work Generally.—Sinking shafts, driving levels, "getting" coal, ironstone, shale and fireclay.

V. Supports.

(1.) Timber.—Kinds of timber used for supporting the sides of excavations. Stocking timber. Advantages of seasoning. Dry rot and its prevention by various methods. Tools and machines for preparing timber.

Modes of timbering shafts, levels and working places. Single props. Prop and lid. Props and bars. Cogs or chocks. Cockermegs. Holing props or sprags. Stulls.

Appliances for withdrawing timber.

(2.) Brickwork, Masonry, and Concrete.—Materials employed. Dry walling. Brick arches. Bricking shafts. Scaffolding employed when lining shafts with brickwork or masonry. Pack walls.

Manner in which concrete is made and used. Advantages and disadvantages of concrete for lining shafts and levels.

(3.) Iron and Steel.—Steel frames for shafts and levels. Various shapes and sizes.

Combination of steel and timber or steel and masonry. Steel and iron supports for working places, with or without the use of timber.

(4.) Special Supporting Processes for Loose, Watery, or Running Strata:—

(*a*) "Spilling," "piling," or "forepoling."
(*b*) Sinking linings.
(*c*) Coffering.
(*d*) Tubbing.
(*e*) Sinking by aid of compressed air.
(*f*) Poetsch or freezing process.
(*g*) Various boring processes with special linings.

VI. Methods of Working.

Classification of methods of working:—

(1.) Subaërial or open workings, or quarries. (2.) Subaqueous workings, dredging, &c. (3.) Wells and boreholes. (4.) Combination of open and underground workings. (5.) Underground workings.

General classification of methods of working underground, viz., (*a*) by permanent pillars; (*b*) by allowing the roof to fall in; (*c*) by filling up the excavations. Considerations determining the position of the shafts. Number, form and dimensions of the shafts. Shaft pillars. Direction of the main haulage roads, size of main road pillars.

Pillar workings. Early method with small pillars; difficulties arising therefrom. Size of pillars in relation to depth.

Longwall. Its advantages and limitations; various modifications.

Special cases of highly inclined or very thick deposits.

VII. Transport.

Classification of methods of transport :—

(1.) Methods not involving the use of rails.

Carriage by persons; shoots and launders; conveyors; pipes; sledges; wheelbarrows; carts; boats.

(2.) Railways.—Waggons, dimensions and mode of construction; rails; sleepers; points; turntables; gradient; resistance; signals. Human power; horses, ponies, mules; stables, feeding; self-acting inclines. Various systems of rope and chain haulage with stationary engines. Steam, compressed air, electric and other locomotives.

(3.) Aerial ropeways.

(4.) Loading and unloading railway trucks and ships.

VIII. Winding.

Machinery and appliances required :—Engines. Drums. Ropes and chains of various kinds. Breaking strains and working loads of ropes and chains. Testing wire ropes. Causes of deterioration of ropes, remedies. Greasing. Examination of ropes. Attachments ("capping"). Pithead frame. Pulleys. Sinking buckets ("bowk" or "hoppet"). Cages. Temporary guides for sinking shafts. Permanent guides or conductors. Keps of various kinds. Onsetting. Landing or banking. Indicators. Safety appliances.

IX. Drainage.

Sources of water met with in mines. Prevention of influx of surface water. Dams of timber, brick, and concrete. Drainage tunnels. Siphons. Winding water by buckets or tanks, and modes of filling and discharging them.

Pumps. Engines above and below ground. Steam pipes carried down the shaft. Transmission of power by rods, water, compressed air and electricity. Lifting pumps, force pumps, valves, columns, counter-balances and safety-catches for rods. Hydraulically driven pumps. Ordinary electric pumps, quick-running electric pumps.

Centrifugal pumps; pulsometer; special pumps for sinking purposes.

Corrosive water. Duty of pumping engines.

Co-operative drainage.

X. Ventilation.

Composition of air. Causes of the pollution of the air of mines: (*a*) Natural gases finding their way into mines, their composition and properties; (*b*) artificial causes of the pollution of the air of mines. Modes of detection of the gases by various methods, and determination of their amount in mine air.

Natural ventilation, its disadvantages and insufficiency.

Artificial ventilation: furnace; mechanical ventilators of various kinds. Calculations as to quantity, pressure, and power. Distribution of the air through the workings. Friction of air currents. "Splitting" of air. Methods of measuring and recording the volume of air passing through the workings. Anemometers. Water gauges. Quantity of air required.

XI. Lighting.

Candles. Lamps; various illuminating materials employed. Safety lamps; principle of the safety lamp. Davy, Clanny, Mueseler, Marsaut, and other safety lamps. Cleaning, filling, lighting, locking, relighting, testing, storing and distributing safety lamps.

Stationary electric lamps for the surface and for pit-bottoms. Electric lamps for sinking pits. Portable electric lamps for working places.

Acetylene lamps. Wells lamp and its congeners.

XII. Descent and Ascent.

Steps and slides. Ladders. Bucket. Cage. Man-engine.

XIII. Dressing.

(1.) Mechanical processes: washing, picking, screening, breaking up by hand, rock-breakers, crushers, stamps, briquette machines, &c.

(2.) Processes depending upon physical properties: motion in water, motion in air, liquefaction and distillation, magnetic attraction, surface adhesion.

(3.) Processes depending upon chemical properties: solution, evaporation, crystallization, atmospheric weathering, calcination, cementation, amalgamation, coking.

Examples of the series of processes employed in pre paring minerals for the market. Sampling.

XIV. Principles of Employment.

Day wages. Contract work by weight or measure. Contracts in which the men have an interest in the value of the mineral extracted.

XV. Legislation.

Classification of mineral workings in the United Kingdom.

Special Acts of Parliament regulating the working of minerals in the United Kingdom:—Coal Mines Regulation Acts, Metalliferous Mines Regulation Acts and Quarries Act. Principal provisions of the Metalliferous Mines Regulation Acts and difference between them and those of the Coal Mines Regulation Acts. General Rules. Special Rules. Factory and Workshop Act. Truck Acts. Workmen's Compensation Act.

XVI. Condition of the Workmen.

Food and clothing. Houses. Barracks. Provident Societies. Health and diseases of the miner. Comparison with other occupations. Hospitals. Amusements. Education.

XVII. Accidents and their Prevention.

Standards by which the danger of the miner's calling may be gauged. Death-rates from accidents per 1,000 persons employed. Comparison with other industries. Death-rates per million tons of mineral raised. Comparison of both kinds of death-rates for the United Kingdom with those of other countries.

Classification of accidents according to the scheme in the Reports of the British Inspectors of Mines.

Average proportion of the total number of deaths due to each class of accident.

Means of preventing each class of accident. Necessity of treating the injured on the spot. Rescue of persons after an explosion or an underground fire.

XVIII. Mineral Statistics.

General information regarding the quantities of the principal minerals obtained in various parts of the world.

The course will include practical work in making exploratory bore-holes; washing ores with the batea, pan, and vanning shovel; sampling minerals for sale; splicing ropes; testing the strength of wire ropes; estimating impurities in air; field and laboratory testing of minerals by dressing processes on an experimental scale. There may be excursions in the neighbourhood of London or in the country for the purpose of visiting mines, quarries and works.

The Associateship in Mining will not be awarded to a student until he has completed, in all, six months' practical experience of underground work in a mine; of this, one-half at least must be completed before the student attends the lectures on Mining; one-half of the whole time should have been spent at a colliery and the other at an ore mine. The six months' practical experience shall mean at least 120 visits underground, each lasting 6 hours underground.

In selecting a mine for practical work the student should consult the Professor of Mining or the Instructor in Mine-Surveying.

Each student must keep a diary, stating how he has been employed, and must make careful notes and sketches while engaged in this practical work. These must be handed to the Instructor in Mine-Surveying in the first fortnight of October each year; the diary must be counter-signed by the managers of the mines at which the student has worked. Diary forms must be obtained from the Registrar or from the Instructor in Mine-Surveying before the vacation. Marks may be awarded for the note-books.

It is not advisable that the student should make tours in mining districts at home or abroad until he has attended the course of lectures in his third year.

In the final examination in Mining, regard will be had to the proficiency of the student in assaying and surveying. No student can pass in Mining unless he has qualified in these two subjects, and it is likewise necessary that he should pass the examination in part I. of Metallurgy.

It is necessary that every mining student should obtain the certificate of the St. John Ambulance Association, and be thus qualified to render first aid to the injured. Instruction in ambulance work by a properly qualified medical man is provided by the Board.

Mine-Surveying.

Practical instruction is carried on every day by the Instructor in Mine-Surveying. The course commences on 15th February, 1904, and closes with the session. It includes the following parts:—

I. Direct measurement of distances; appliances in common use, and their modes of employment in various circumstances. Sources of error

in linear measurements, their relative importance and the precautions which may be taken to avoid or reduce error.

II. SURVEYS DEPENDING MAINLY ON LINEAR MEASUREMENTS with the chain, steel-band, etc. The auxiliary instruments employed.

III. SURVEYING WITH THE MAGNETIC COMPASS. Form, construction and use of various instruments, in which the magnetic needle plays a principal part, *e.g.* the simple mine-dial, the hanging compass, the prismatic compass, the Brunton clinometer-compass, etc. The manner in which compass-surveys may be carried on in the neighbourhood of iron.

IV. THE THEODOLITE: Various forms including the compass-theodolites or circumferentors, and, in particular, the transit theodolite with centric telescope and additional or interchangeable eccentric telescope, as specially modified for underground work.

Methods of measuring horizontal and vertical angles by means of the transit theodolite with centric telescope.

The various ways in which the transit theodolite with eccentric telescope may be employed for the same purposes.

Theory of the effect of errors of construction or adjustment of the transit theodolite on the measurement of angles and of their partial compensation by "transiting" and repeating the measurement. Manner of making the adjustments.

V. THE PLANE-TABLE and other instruments in which the angles are graphically recorded, *e.g.* the Rapid Traverser.

VI. TRAVERSING at the surface with the theodolite, circumferentor or goniograph. Various methods of measuring the polygonal angle, the "angle of deflection" and the bearings or angles of direction with and without the aid of the magnetic needle. Traversing underground and the special appliances necessary thereto. Comparison of the various methods showing their special applicability in different circumstances.

VII. THE MEASUREMENT OF DIFFERENCES OF ALTITUDE. The Dumpy and the Y Levels; their construction and adjustments.

The effect of the earth's curvature and refraction in levelling over long distances; equal distance levelling; levelling from the two ends of a line; levelling underground; mine-levelling staves, etc. Various modes of recording and reducing the observations.

Levelling by means of the vertical circle of various instruments.

Measurement of the depths of shafts.

Use of the aneroid barometer.

VIII. COMBINED SURVEYING AND LEVELLING OPERATIONS; contouring in general; tacheometry, photogrammetry, etc.

IX. Finding the latitude and meridian of a place.

X. MINOR TRIANGULATION and its object. Measurement of base-lines. Connection of a minor triangulation with the great trigonometrical survey of a country or region. The three point problem. The problem of the two points or inaccessible distance.

XI. CONNECTION OF THE UNDERGROUND AND SURFACE SURVEYS. Connection through an adit, slope or shaft of moderate inclination. Connection by a theodolite survey through one steeply-inclined shaft—special sources of error in the orientation of an underground survey when this method only is available. Connection by means of two shafts. Connection through one vertical shaft by various plumbing methods. The transit instrument method. Orientation by means of the magnetic needle; the use of various special orientation instruments, *e.g.* Breithaupt's, Schmidt-Neumayer's, Fennel's, etc.

XII. SETTING OUT: giving and maintaining direction and gradient for inclined shafts, slopes, levels, etc.; setting out at the surface. Laying out mining claims, etc. Ranging curves in horizontal and vertical planes.

XIII. OFFICE-WORK: Calculation of plane rectangular co-ordinates and various problems in connection therewith. Plotting and finishing

mine plans, sections, etc. Copying plans. Mine models. Calculating and estimating areas, volumes and masses. Other mine-surveying problems.

Special attention is given to field-work; a few weeks will be spent at a mine in Surrey, Wales, or elsewhere, for practice in underground surveying.

Students will be required to provide themselves with the following articles:—

Mathematical instruments.
Rolling parallel ruler.
Protractor (12″ cardboard is suitable).
Drawing-board.
Tee and set squares.
Lettering squares.
Set of scales with offsets to match.
Set of water-colours and brushes.
Drawing paper, pins, and hard pencils.
Three note-books.
Logarithmic tables.
Waterproof inks (black and coloured).
Camel's hair brush for dusting.
Light plumb-bob.
Sandwich-tin or wallet.
Blowpipe.

Particulars of these may be obtained from the Instructor

List of Students to whom Scholarships, Medals and Prizes have been awarded.

The Duke of Cornwall's Scholarship.

Session	1851–2	Henry Francis Blanford.
,,	,, (for one year)	Robert Hunt.
,,	1852–3	William Thomas Blanford.
,,	1853–4	Frederic Drew.
,,	1854–5	Charles Gould.
,,	1855–6	John Morland.
,,	1856–7	William Weston.
,,	1857–8	Clement Le Neve Foster.
,,	1858–9	Thomas William Danby.
,,	1859–60	William Hackney.
,,	1860–61	Frederick Charles Bishopp.
,,	1861–62	Edward B. Tawney.
,,	1862–63	Frederick G. Finch.
,,	1863–64	Riccardo Molteni.
,,	1864–65	William Thomas Rowden.
,,	1865–66	Edward Richards.
,,	1866–67	Henry A. Black.
,,	1867–68	German Green.
,,	1868–69	William J. Sollas.
,,	1869–70	Percy Carlyle Gilchrist.
,,	1870–71	George M. Dawson.
,,	1871–72	Edgar Jackson.
,,	1872–73	Conwy Lloyd Morgan.
,,	1873–74	Ambrose R. Willis.
,,	1874–75	Henry Louis.

Royal Scholarships.

1855.	1st Year's Student, 25*l.* to	Ambrose Tween.
,,	2d Year's Students, 15*l.* to	Frederic Drew. George P. Wall.
1856.	1st Year's Students, 25*l.* to	Edward Matthey. Mark Bullen.
,,	2d Year's Students, 15*l.* to	Charles Gould. Ambrose Tween.
1857.	2d Year's Students, 15*l.* to	Richard Thornton. John Morland.
1858.	1st Year's Student, 15*l.* to	T. W. Danby.
,,	2d Year's Student, 25*l.* to	Ch. S. Wood.
,,	2d Year's Student, 15*l.* to	William Weston.
1859.	1st Year's Students, 15*l.* to	William Hackney. Walter Child.
,,	2d Year's Student, 25*l.*	*Not awarded.*
1860.	1st Year's Students, 15*l.* to	F. C. Bishopp. Clement Wilkinson.
,,	2d Year's Student, 25*l.* to	Walter Child.

1861.	1st Year's Student, 15*l.* to	E. B. Tawney.
„	2d Year's Student, 25*l.* to	Clement Wilkinson.
*1863.	1st Year's Students, 15*l.* to	Thos. Gibb. Cornelius O'Sullivan.
„	2d Year's Student, 25*l.* to	Thos. Gibb.
1864.	1st Year's Students, 15*l.* to	W. T. Rowden. Charles Berrell.
„	2d Year's Student, 25*l.* to	Cornelius O'Sullivan.
1865.	1st Year's Students, 15*l.* to	G. Snelus. W. Thorp.
„	2d Year's Student, 25*l.* - -	*Not awarded.*
1866.	1st Year's Students, 15*l.* to	Edward Collens. Henry A. Black.
„	2d Year's Student, 25*l.* to	G. Snelus.
1867.	1st Year's Students, 15*l.* to	F. J. M. Page. German Green.
„	2d Year's Student, 25*l.* to	E. Collens.
1868.	1st Year's Students, 15*l.* to	A. W. Bickerton. William J. Sollas.
„	2d Year's Student, 25*l.* to	Gordon Broome.
1869.	1st Year's Student, 15*l.* to	J. J. Bowrey.
„	1st and 2d Year's Student 40*l.* to	William Gowland.
1870.	1st Year's Students, 15*l.* to	W. H. Greenwood. F. C. Milford.
„	2d Year's Student, 25*l.* to	RobertWm.Atkinson.
1871.	1st Year's Students, 15*l.* to	W. Charlton. Channell Law.
„	2d Year's Student, 25*l.* to	W. H. Greenwood.
1872.	1st Year's Students, 15*l.* to	S. H. Hill. Jas. Taylor.
„	2d Year's Student, 25*l.* to	Channell Law.
1873.	1st Year's Students, 15*l.* to	W. Carter. A. G. Meeze.
„	2d Year's Student, 25*l.* to	S. A. Hill.
1874.	1st Year's Students, 15*l.* to	Henry Louis. E. F. Pittman.
„	2d Year's Student, 25*l.* to	W. F. Lowe.
1875.	1st Year's Students, 15*l.* to	A. N. Pearson. L. J. Whalley.
„	2d Year's Student, 25*l.* to	W. Hewitt.
1876.	1st Year's Students, 15*l.* to	T. E. Holgate. F. G. Mills.
„	2d Year's Student, 25*l.* to	A. N. Pears
1877.	1st Year's Students, 15*l.* to	R. W. L W. M
„	2d Year's Student, 25*l.* to	F.
1878.	1st Year's Students, 15*l.* to	It
„	2d Year's Student, 25*l.* to	

* In 1862 these prizes were div

1879. 1st Year's Students, 15*l.* to	J. J. Hood. J. F. Wilkinson.
„ 2d Year's Student, 25*l.* to	R. G. Scott.
1880. 1st Year's Students, 15*l.* to	J. E. Green. C. H. Powell.
„ 2d Year's Student, 25*l.* to	J. J. Hood.
1881. 1st Year's Students, 15*l.* to	H. F. Collins. R. T. Bodey.
„ 2d Year's Student, 25*l.* to	J. P. Walton.

ROYAL COLLEGE OF SCIENCE.

1882. 1st Year's Students, 15*l.* to	Alfred Sutton. Herbert W. Hughes. Thomas Mather. Henry G. Graves.
„ 2d Year's Students, 25*l.* to	Henry F. Collins. Ralph T. Bodey.
1883. 1st Year's Scholarships	Isaac T. Walls. George Gibbens. John H. Tomlinson. Alfred Fowler.
„ 2d Year's Scholarships	Alfred Sutton. Henry G. Graves.
1884. 1st Year's Scholarships	Albert G. Hadcock. Fred. Carrodus. William C. Rowden. Thomas Rose.
„ 2d Year's Scholarships	George Gibbens. Isaac T. Walls.
1885. 1st Year's Scholarships	James W. Rodger. Andrew McWilliam. Tom H. Denning. John Richards.
„ 2d Year's Scholarships	Alfred E. Tutton. Thomas Rose.
1886. 1st Year's Scholarships	William Blackmore. James Young. Charles Lang. Henry E. Hadley.
„ 2d Year's Scholarships	Andrew McWilliam. John Richards.
1887. 1st Year's Scholarships	Samuel B. Asher-Aron. William Tate. James A. Schofield. Savannah J. Speak.
„ 2d Year's Scholarships	William Blackmore. Henry Sowerbutts

1888.	1st Year's Scholarships - -	Samuel H. Studley. Sidney Wood. William S. Jarratt. George N. Huntly.
„	2d Year's Scholarships - -	Savannah J. Speak. William Tate.
1889.	1st Year's Scholarships - -	Lionel M. Jones. Joseph Jefferson. James G. Lawn. Herbert Grime.
„	2d Year's Scholarships - -	Samuel H. Studley. William S. Jarratt.
1890.	1st Year's Scholarships - -	John W. Pickles. Herbert J. Woodall. Walter E. Harrison. Charles L. E. Heath.
„	2d Year's Scholarships -	Lionel M. Jones. Herbert Grime.
1891.	1st Year's Scholarships - -	William Allan. Thomas T. Bedford. Edwin Edser. Herbert A. Clark.
„	2d Year's Scholarships - -	John W. Pickles. Sydney Whalley.
1892.	1st Year's Scholarship - -	Bernard E. Spencer. George S. West. Charles J. Gray. Harry Verney.
„	2d Year's Scholarships - -	George R. Melton. Laurence Parry.
1893.	1st Year's Scholarships - -	Robert W. Forsyth. George W. Walker. John Thomas. Harry R. Prescott.
„	2d Year's Scholarships - -	Bernard E. Spencer. George S. West.
1894.	1st Year's Scholarships - -	Robert Sowter. Arthur O. Allen. Henry T. Davidge. John B. Chambers.
„	2d Year's Scholarships - -	Robert W. Forsyth. William Longshaw.
1895.	1st Year's Scholarships - -	Ernest Smith. Geo. Marks Russell. Frank Fisher Norton Baron.
„	2d Year's Scholarships - -	Robert Sowter. Joe Crowther.

1896. 1st Year's Scholarships -	John William Barker. Charles Ernest Goodyear. Edmund Rycroft Verity. Ernest Thomas Harrison.
„ 2d Year's Scholarships -	William Herbert White. Ernest Smith.
1897. 1st Year's Scholarships -	Harry Egerton Wimperis. George John Fenwick. John Cresswell. Philip George Gundry.
, 2d Year's Scholarships -	Ernest Thomas Harrison. John William Barker.
1898. 1st Year's Scholarships -	Charles Henry Stewart. Paul Sidney Couldrey. Albert Hall. John Abercromby Brown.
„ 2d Year's Scholarships -	Ernest William John Edwards. George John Fenwick.
1899. 1st Year's Scholarships -	George Marshall Norman. John Satterly. George Stevenson Taylor. Victor George Alexander.
, 2d Year's Scholarships -	Albert Hall. George Henry Broom.
1900. 1st Year's Scholarships -	Wilfred Harry Clarke. George William Clarkson Kaye. Arthur John Spencer. William Morrish Selvey.
„ 2d Year's Scholarships -	George Marshall Norman. John Satterly.
1901. 1st Year's Scholarships -	Albert Edwin Dodridge. George Herbert Green. Sidney George Burrow. Frederick Percy Rolfe.
„ 2d Year's Scholarships -	Wilfred Harry Clarke. George William Kaye.
1902. 1st Year's Scholarships -	John Beardsmore Homer. Alfred Shepherd. Alfred William Steed. Henry James Jones.
„ 2d Year's Scholarships -	George Herbert Green. Sidney George Burrow.

1903. 1st Year's Scholarships	Donald Francis Blyther. William Welch. William Feast. Herbert George Tisdall.
„ 2d Year's Scholarships	John Beardsmore Homer. Alfred William Steed.

The Edward Forbes Medal and Prize of Books.

ROYAL SCHOOL OF MINES.

Awarded in—

1855 to Frederic Drew.
1856 to Charles Gould.
1857 to John Morland.
1858 *No Candidate.*
1859 to Clement Le Neve Foster.
1860 to Thomas William Danby.
1861 to Walter Child.
1862 to Frederick C. Bishopp.
1863 to E. B. Tawney.
1864 to J. Clifton Ward.
1865 to A. C. Maybury.
1866 *Not awarded.*
1867 to David Watson.
1868 *Not awarded.*
1869 *Not awarded.*
1870 *No competition.*
1871 to T. Jeffrey Parker.
1872 to G. M. Dawson.
1873 to George Smith.
1874 to Ambrose R. Willis.
1875 *Not awarded.*
1876 to W. Hewitt.
1877 to Angelo Heilprinn.
1878 to Percy F. Frankland.
1879 *Not awarded.*
1880 to H. M. Platnauer.
1881 *Not awarded.*

ROYAL COLLEGE OF SCIENCE.

Awarded in—

1882 to Charles J. Gahan.
1883 to Richard S. Wray.
1884 to Thomas Johnson.
1885 to Alfred V. Jennings.
1886 to Arthur C. Jones.
1887 to Agnes Calvert.
1888 to Arthur M. Davies.
1889 to George Brebner.
1890 to Claude H. C. Woodhouse.
1891 to Arthur G. Butler.
1892 to William West.*
1892 to John H. Vanstone.*
1893 to Henry B. Lacey.
1894 to George Stephen West.
1895 to William George Freeman.
1896 to Ernest Charles Horrell.
1897 to Herbert Spencer Harrison.
1898 to Thomas George Hill.
1899 to Una Lyon.
„ to Herbert Wright.
1900 to Frank Cavers.
1901 to Eric Drabble.
1902 to Louis Edward Robinson.
1903 to Horace Athelstan Wager.

Marshall Scholarship.

Awarded in—

1892–93 to H. M. Bernard.
1893–94 to Jesse Reeves.
1894–95 to J. E. S. Moore.
1895–96 to J. Lloyd Williams.
1896–97 to George P. Mudge.
1897–98 to Arthur J. Maslen.
1898–99 to Thomas George Hill.
1899–1900 to Henry Hurd Swinnerton.
1900–01 to William Brough Randles.
1901–02 to Robert Lionel Sherlock.
1902–03 to Thomas Thornton.
1903–04 to Dorothy Shove.

* Two Medals and Prize divided.

The De la Beche Medal.

ROYAL SCHOOL OF MINES.

Awarded in—

1857 to Richard Thornton.
1858 to William Weston.
1859 to Ch. S. Wood.
1860 to Thomas William Danby.
1861 to William Hackney.
1862 to Clement Wilkinson.
1863 to E. B. Tawney.
1864 to F. Gordon Davis.
1865 to Riccardo Molteni.
1866 to W. T. Rowden.
1867 to George Snelus.
1868 *Not awarded.*
1869 to Gordon Broome.
1870 to William Gowland.
1871 to Frank Taylor.
1872 to W. Charlton.
1873 to Edgar Jackson.
1874 to Conwy Lloyd Morgan.
1875 to George Fitz-Brown.
1876 to Henry Louis.
1877 to Edward W. Voelcker.
1878 to F. G. Mills.
1879 to A. D. Ellis.
1880 to John Greene.
1881 to H. H. Hoffert.

ROYAL COLLEGE OF SCIENCE.

Awarded in—

1882 to C. H. Powell.
1883 to Thomas Turner.
1884 to Herbert W. Hughes.
1885 to Henry G. Graves.
1886 to John C. Little.
1887 to William J. Sharwood.
1888 to Edmund L. Hope.
1889 to Samuel J. Trusbott.
1890 to Geoffrey Marshall.
1891 to James G. Lawn.
1892 to Lewis H. Cooke.
1893 to Samuel Warren Price.
1894 to John Ball.
1895 to Robert William Pringle.
1896 *Not awarded.*
1897 to Hans Sören Meyer.
1898 to George Alfred Stonier.
1899 *Not awarded.*
1900 *Not awarded.*
1901 to Stanley Charles Dunn.
1902 *Not awarded.*
1903 to Frederick Percy Rolfe.

The Murchison Medal and Prize of Books.

ROYAL SCHOOL OF MINES.

Awarded in—

1862 to Theodore Hughes.
1863 to Frederick G. Finch.
1864 to Richard Googan.
1865 to W. T. Rowden.
1866 to Edward Richards.
1867 to Edward Collens.
1868 to F. J. M. Page.
1869 to William Gowland.
1870 to Percy Carlyle Gilchrist.
1871 to George M. Dawson.
1872 to Stephen W. Davies.
1873 to C. Lloyd Morgan.
1874 to Ambrose R Willis.
1875 to George Seymour.
1876 to W. Hewitt.
1877 to Frederick G. Mills.
1878 to Manuel M. Terrero.
„ to Syed Ali (*extra medal*).
1879 to B. Mott.
1880 to H. M. Platnauer.
1881 to M. Staniland, junior.

ROYAL COLLEGE OF SCIENCE.

Awarded in—

1882 to H. F. Collins.
1883 to William P. Wynne.
1884 to Martin F. Woodward.
1885 to Alfred E. Tutton.
1886 The Medal to James Allen.
1886 The prize of books to James W. Rodger.
1887 to Thomas H. Holland.
1888 Books to William Tate and Samuel J. Truscott (*medal not awarded*)
1889 Books to William Watson. Medal to John W. Evans.
1890 Books to Herbert Grime and James G. Lawn (*medal not awarded*).
1891 to Charles G. Cullis.
1892 to Sidney G. Starling.
1893 to Joseph B. Morgan.
1894 Books to John J. Green and Francis C. Harrison (*medal not awarded*).
1895 to John Caspell.
1896 to Ernest Edward Leslie Dixon.
1897 to Joseph Lister.
1898 to John Allen Howe.
1899 to Robert Lionel Sherlock.
1900 to Lewis Leigh Fermor.
1901 to Arthur Howard Higgins.
1902 to Hilda Mary Judd. Hubert Cecil Jones.
1903 Books to Malcolm Wilson and Claude George Sara (*medal not awarded*).

The Bessemer Medal and Prize of Books.

ROYAL SCHOOL OF MINES.

Awarded in—

1881 to J. J. Hood.

ROYAL COLLEGE OF SCIENCE.

Awarded in—

1882 to F. W. Harbord.
1883 to Henry F. Collins.
1884 to Percy Bosworth Smith.
„ a prize of books to William F. Grace.
1885 to John C. Little. James Allen.
1886 to Frederick H. Holland.
1887 to John J. Richards.
1888 to Henry C. Jenkins.
1889 to Richard Stanfield.
1890 to David Wilkinson.
1891 to Joseph Jefferson.
1892 to Harold Jeans.
1893 to Allan Gibb.
1894 to Charles H. Sidebotham.
1895 to John Collett Moulden.
1896 to Joe Crowther.
1897 to George Hardy Stanley.
1898 to George Patchin.
1899 to Charles Olden Bannister.
1900 to Edward Perchard Dunn.
1901 to Peter Quartano.
1902 to William Henry Goodchild.
1903 to Otmar Ulrich Seeman.

The Tyndall Prize.

ROYAL COLLEGE OF SCIENCE.

Awarded in—

1882 to W. J. Burgess.
1883 to William P. Wynne.
1884 to Isaac T. Walls.
1885 to Alfred E. Tutton.
1886 { 1st Term, John H. Powell. / 2nd Term, Henry C. Jenkins.
1887 to James W. Rodger.
1888 to William Watson.
1889 to James G. Lawn.
1890 to George H. Perry.
1891 to William Allan
1892 to Bernard Eric Spencer.
1893 to George D. Dunkerley.
1894 to Robert Sowter.
1895 to William Herbert White.
1896 to Ernest Thomas Harrison.
1897 to Harry Egerton Wimperis.
1898 to Dan Robinson.
1899 to John Satterly.
1900 to Arthur John Spencer.
1901 to Albert Edwin Doddridge.
1902 to James Henry Reeves.
1903 to Charles Cook.

The Hodgkinson Prize.

Awarded in—

1882 to C. A. White.
1883 1st Prize, Samuel C. Hooker.
„ 2nd Prize, Richard H. Adie.
1884 1st Prize, George T. Holloway.
„ 2nd Prize { Stephen J. Elliott. / William P. Wynne.
1885 1st Prize, Arthur W. Bishop.
2nd Prize, Peter S. Buik.
1886 { 1st Prize, Thomas H. Greenall. / 2nd Prize, Alfred E. Tutton.
1887 { 1st Prize, John T. Hewitt. / 2nd Prize, William E. Hotson.

The Frank Hatton Prize.

Awarded in—

1886 to Alfred E. Tutton.
1887 to John T. Hewitt.
1888 to James W. Rodger.
1889 to James Kelly.
1890 to George N. Huntly.
1891 { to Herbert Grime. / to Lionel M. Jones.
1892 to George H. Perry.
1893 to Robert E. Barnett
1894 to John Thomas.
1895 to William Longshaw.
1896 to Gilbert Thomas Morgan.
1897 to Harry Burrows.
1898 to Joseph Lister.
1899 to William Robertson.
1900 to Hubert William Bywaters.
1901 to Mary Boyle.
1902 to John Herman Binder.
1903 to Hamilton McCombie.

The Warington Smyth Medal and Prize.

Awarded in—

1900 to George Alfred Stonier.
1901 *Not awarded.*
1902 *Not awarded.*
1903 *Not awarded.*

The Edward Matthey Prize.

Awarded in—

1900 to Alfred Jeffreson Brett.
1901 to William H. Merrett.
1902 to Charles Olden Bannister.
1903 to Ernest Alfred Wraight.

The Huxley Medal.

Awarded in—

1902 to John E. S. Moore.
1903 *Not awarded.*

Prizes of Books given by the Board of Education.

Mechanics.

Awarded in—

1888 to James Whitaker.
1889 to William Buchanan.
1890 to William W. F. Pullen.
1891 to Charles H. Kilby.
1892 to John G. Longbottom.
1893 to William H. Pretty.
1894 to Harold R. Cullen.
1895 to Cecil A. S. Baxter. Frederick C. Lea.
1896 to Frank Fisher.
1897 to Edmund Rycroft Verity.
1898 to Harry Jackson.
1899 to Frederick John Tyley.
1900 to Howard Melville Rootham.
1901 to Leonard Bairstow.
1902 to Walter Alfred Scoble.
1903 to Alec James Simpson.

Astronomical Physics.

Awarded in—

1888 to William S. Jarratt and William Watson.
1889 to John B. Coppock.
1890 to Lewis H. Cooke.
1891 to Charles P. Butler. Laurence Parry. Herbert A. Clark. Samuel S. Richardson.
1892 to James Bruce.
1893 to William E. Tubbs. Willie Whalley.
1894 to Francis Richard Penn. Robert Sowter.
1895 to Ernest E. L. Dixon. William H. White.
1896 to William Allan Picknett.
1897 to John Cresswell.
1898 to Andrew Steedman.
1899 to Leonard Bairstow.
1900 to Howard Ernest Goodson.
1901 to Sidney George Burrow.

Practical Chemistry.

Awarded in—

1888 to James W. Rodger and James Young.
1889 to James Kelly.
1890 to George N. Huntly.
1891 to William A. C. Rogers.
1892 to George H. Perry.
1893 to Robert E. Barnett. Gerald G. Quinn.
1894 to Bouchier M. C. Marshall.
1895 to Henry W. Hutchin.
1896 to Gilbert Thomas Morgan.
1897 to Harry Burrows.
1898 to James Hart-Smith.
1899 to George John Fenwick.
1900 to Oswald Freeman Hudson.
1901 to Robert Gillespie.
1902 to Herbert Ben Winfield.
1903 to Hamilton McCombie.

Mining.

Awarded in—

1888 to John M. Beckwith.
1889 to Samuel J. Truscott.
1890 to Geoffrey Marshall.
1891 to James G. Lawn.
1892 to Lewis H. Cooke.
1893 to Samuel W. Price.
1894 to John Ball.
1895 to Robert W. Pringle.
1896 to Osmer Bernard Ward.
1897 to Hans Sören Meyer.
1898 to Leonard Cecil Stuckey.
1899 to Alfred Fox.
1900 to Charles Henry Stewart.
1901 to Stanley Charles Dunn.
1902 to Roland Lee Hewitt. Arthur Clive Nicholson.
1903 to Frederick Percy Rolfe.

Principles of Agriculture and Agricultural Chemistry.

1888 *Not awarded.*
1889 to William Scudamore.
1890 to Robert Adams.
1891 to Henry Wilkinson.
1892 to Thomas Jones.
1893 to Robert S. Seton.
1894 to William Wilson.
1895 to William Williams.
1896 *Not awarded.*
1897 *Not awarded.*
1898 to Francis William Oldfield.

Mathematics.

Awarded in—

1902 to Edward Charles Moyle.
1903 to Sidney George Burrow.

Physics.

Awarded in—

1903 to Sidney George Burrow.

Scholarships given by the Institution of Mining and Metallurgy.

Awarded in—

1903 to Henry Trench Waller (Metallurgy). Frederick Percy Rolfe (Mining).

Associates of the Royal School of Mines, 1851 to 1881.

Session.	Name.	Division.
1878–81	BAKER, CHARLES K.	Metallurgy.
1852–54	BAKER, WILLIAM	Metallurgy and Geology.
1868–71	BALLARD, E. G.	Metallurgy.
1878–81	BANON, HENRY C.	Metallurgy.
1869–74 and 1875–76	BARRY, J. H.	Mining.
1851–53	BAUERMAN, HILARY	Mining, Metallurgy, and Geology.
1866–70	BAYLY, FRANCIS WILLIAM	Metallurgy.
1873–75	BECHER, HARRY M.	Mining and Metallurgy.
1870–73	BELL, HENRY STOWE	Metallurgy.
1861–65	BELL, JOSEPH CARTER	Metallurgy.
1866–69	BELL, WILLIAM GOMM	Metallurgy.
1877–80	BENSON, ROBERT SEYMOUR.	Metallurgy.
1876–79	BENTON, W. E.	Mining.
1877–80	BERINGER, JOHN J.	Metallurgy.
1867–70	BICKERTON, A. W.	Metallurgy.
1877–80	BIRD, DAVID DRUCE	Metallurgy.
1859–62	BISHOPP, FREDERICK C.	Mining, Metallurgy, and Geology.
1851–53	BLANFORD, HENRY F.	Mining, Metallurgy, and Geology.
1852–54	BLANFORD, WILLIAM T.	Mining, Metallurgy, and Geology.
1877–81	BLYTH, H. G.	Metallurgy.
1875–78	BOUCHER, ARTHUR S.	Mining and Metallurgy.
1873–76	BOYS, CHARLES VERNON	Mining and Metallurgy.
1866–69	BROOME, GORDON	Mining and Metallurgy.
1878–81	BROUGH, BENNETT H.	Metallurgy.
1862–64	BROWN, CHARLES B.	Geology.
1865–69	BROWNE, LEONARD	Metallurgy.
1866–69	BUTLER, FRANCIS H.	Geology.
1873–76	CAMPBELL, A. J.	Mining.
1875–78	CAWLEY, JOHN	Mining and Metallurgy.
1876–79	CHARLETON, A. G.	Mining.
1870–72	CHARLTON, WILLIAM	Mining and Metallurgy.
1858–61	CHILD, WALTER	Mining, Metallurgy, and Geology.
1874–78	CLAY, RANDOLPH	Metallurgy.
1874–78	CLAUDET, ARTHUR C.	Metallurgy.
1865–68	CLOUD, THOMAS CHARLES	Metallurgy.
1874–77	COPELAND, ARTHUR	Metallurgy.
1877–80	COTTON, HENRY S.	Metallurgy.

Session.	Name.	Division.
1871–74	COWPER, RICHARD -	Mining and Metallurgy.
1872–74	COX, SAMUEL H. -	Mining.
1875–80	CRICK, GEORGE C. -	Geology.
1874–78	CRIPER, WILLIAM R. -	Metallurgy.
1879–81	CROOKES, HENRY -	Metallurgy.
1877–80	CROSS, WILLIAM - -	Metallurgy.
1857–60	DANBY, THOMAS WILLIAM	Geology.
1876–79	DAVIDSON, W. B. M. -	Metallurgy.
1870–73	DAVIES, STEPHEN WM. -	Metallurgy.
1875–78	DAVISON, ROBERT A. P. -	Metallurgy.
1869–72	DAWSON, GEORGE MERCER	Mining and Geology.
1874–76	DE FERRARI, PAULO -	Mining.
1873–76	DE GONCER, JOSÉ -	Mining and Metallurgy.
1868–72	DILLON, EDWARD -	Mining and Metallurgy.
1853–55	DREW, FREDERIC - -	Mining, Metallurgy, and Geology.
1858–61	DUNN, HENRY BARTRAM -	Mining and Geology.
1874–78	EASTICK, JOHN JOSEPH	Metallurgy.
1875–79	ELLIS, A. D. - -	Mining.
1875–78	ELLIS, W. A. - -	Metallurgy.
1857–59	FEDDEN, FRANCIS -	Mining and Geology.
1877–79	FELL, E. N. - -	Mining.
1861–64	FINCH, FREDERICK G. -	Geology.
1876–79	FISON, A. H - -	Metallurgy.
1872–75	FITZ-BROWN, GEORGE -	Metallurgy.
1874–77	FOLKARD, CHARLES W. -	Mining and Metallurgy.
1857–59	FOSTER, CLEMENT LE NEVE	Mining, Metallurgy, and Geology.
1873–75	FRAMES, G. C. - -	Geology.
1875–78	FRANKLIN, PERCY F. -	Geology.
1866–69	FRECHEVILLE, ROBERT J.	Metallurgy.
1871–75	FRECHEVILLE, WILLIAM -	Mining, Metallurgy, and Geology.
1862–63	GIBB, THOMAS - -	Mining and Metallurgy.
1868–71	GILCHRIST, D. CARLYLE -	Mining and Metallurgy.
1854–56	GOULD, CHARLES - -	Mining, Metallurgy, and Geology.
1868–70	GOWLAND, WILLIAM -	Mining and Metallurgy.
1877–80	GRANT, WILLIAM LOUIS -	Metallurgy.
1875–78	GRAY, JOHN - -	Metallurgy.
1873–76	GRAY, M. H. - -	Mining.
1866–69	GREEN, GERMAN - -	Metallurgy and Geology.
1877–80	GREENE, JOHN - -	Mining.
1875–78	GREENWELL, LEONARD W.	Metallurgy.
1869–71	GREENWOOD, W. H. -	Metallurgy.
1876–79	GREY, F. W. - -	Metallurgy.
1863–66	GRIFFITH, N. R. - -	Mining.

Session.	Name.	Division.
1865–68 and 1872–73	GRIFFITHS, J. ALFRED	Mining and Metallurgy.
1876–80	GRUNDY, GRAHAM S.	Metallurgy.
1871–74	GUERARD, ARTHUR ROSE	Mining and Metallurgy.
1872–76	GUNN, HENRY H.	Mining.
1858–61	HACKNEY, WILLIAM	Mining, Metallurgy, and Geology.
1873–7 and 1879	HALSE, EDWARD	Metallurgy.
1869–72	HARROLD, FR. WM.	Metallurgy.
1873–75	HELLON, ROBERT	Metallurgy.
1876–79	HARVEY, E. W.	Metallurgy.
1873–76	HEWITT, W.	Mining, Metallurgy, and Geology.
1877–80	HIGGINS, CHARLES L.	Metallurgy.
1875–79	HILL, MALCOLM	Metallurgy.
1876–81	HOFFERT, H. H.	Mining, Metallurgy, and Geology.
1874–77	HOGAN, JAMES F.	Metallurgy.
1875–78	HOLGATE, THOMAS E.	Mining and Metallurgy.
1878–81	HOOD, JOHN JAMES	Metallurgy.
1878–81	HOOKER, BRIAN H. H.	Metallurgy.
1873–76	HOWARD, WILLIAM	Mining.
1874–78	HOWELL, REGINALD	Metallurgy.
1871–74	HILL, SAMUEL ALEXANDER	Mining, Metallurgy, and Geology.
1859–62	HUGHES, THEODORE	Metallurgy and Geology.
1851–53	HUNT, ROBERT	Mining, Metallurgy, and Geology.
1874–77	HUNTINGTON, ALFRED R.	Mining and Metallurgy.
1869–72	HUXLEY, JAMES HENRY	Metallurgy.
1874–78	INGALL, ELFRIC D.	Metallurgy.
1871–73	JACKSON, EDGAR	Mining and Metallurgy.
1875–78	JACOB, ERNEST	Mining.
1870–73	JEFFERSON, JOHN CLARK	Metallurgy.
1876–80	JONES, E. J.	Geology.
1865–70	JONES, THOS.	Metallurgy.
1875–78	KEEP, WILLIAM	Mining and Metallurgy.
1878–81	KENSINGTON, ARTHUR	Metallurgy.
1872–76	KITCHENER, ARTHUR B.	Mining.
1870–73	LAW, CHANNELL	Mining and Metallurgy.
1872–77	LEMANN, CHARLES HENRY	Metallurgy.
1859–63	LEVICK, THOMAS	Mining.
1874–77	LEYSON, WILLIAM	Metallurgy.
1877–80	LINDON, EDWARD BYROM	Mining and Metallurgy.
1873–77	LIVEING, EDWARD	Mining.

Session.	Name.	Division.
1867–70	LIVERSIDGE, ARCHIBALD -	Mining and Metallurgy.
1872–76	LOTT, FRANK E. - -	Mining and Metallurgy.
1873–76	LOUIS, HENRY - -	Mining and Metallurgy.
1871–75	LOWE, WILLIAM FOULKES	Metallurgy.
1876–79	LUCAS, J. H. - -	Metallurgy.
1874–77	MCCARTHY, EDWARD T. -	Metallurgy.
1878–80	MCNEIL, BEDFORD -	Metallurgy.
1876–79	MARSH, WALTER - -	Metallurgy.
1872–75	MARSHALL, FRANK HERBERT	Mining and Metallurgy.
1878–81	MARSHALL-HALL, J. E. -	Mining.
1878–81	MATHESON, RODERICK MCK. C.	Metallurgy.
1855–57	MATTHEY, EDWARD -	Metallurgy.
1866–69	MAURY, MATTHEW F. -	Mining and Metallurgy.
1875–78	MAY, T. H. D. - -	Mining and Metallurgy.
1862–65	MAYBURY, AUGUSTUS C. -	Geology.
1864–65 and 1878–80	MENTEATH, P. W. STUART	Mining and Metallurgy.
1874–77	MERRITT, W. HAMILTON -	Mining.
1869–72	MILLER, HUGH - -	Geology.
1875–78	MILLS, FREDERICK G. -	Mining and Metallurgy.
1876–79	MIRZA MEHDJ KHAN -	Mining and Metallurgy.
1863–65	MOLTENI, RICCARDO -	Geology.
1869–72	MONDY, EDMUND FELIX -	Metallurgy.
1854–56	MONTEIRO, JOACHIM JOHN	Metallurgy.
1855–57	MORELAND, JOHN- -	Metallurgy and Geology.
1871–74	MORGAN, CONWY LLOYD -	Mining and Metallurgy.
1876–80	MOTT, B. - - -	Mining.
1875–79	OLDHAM, RICHARD D. -	Geology.
1875–78	PADLEY, CHARLES S. -	Mining and Metallurgy.
1866–69	PAGE, F. J. MONTAGUE -	Mining and Metallurgy.
1868–71	PARKER, T. JEFFERY -	Geology.
1859–61	PEACH, BENJAMIN -	Geology.
1871–74	PEARCE, WALTER - -	Metallurgy.
1869–72	PEGLER, OLIVER - -	Mining and Metallurgy.
1870–73	PHILLIPS, ARTHUR GAVED	Mining and Metallurgy.
1869–75	PINCHING, ARCHIBALD E.-	Mining.
1873–76	PITTMAN, EDWARD F. -	Mining and Metallurgy.
1877–80	PLATNAUER, H. M. -	Geology.
1864–67	POOLE, HENRY S. -	Geology.
1862–65	POTTER, FREDERICK A. -	Metallurgy.
1873–76	PRESSLAND, EDWARD B. -	Mining and Metallurgy.
1872–75	PURDIE, THOMAS - -	Metallurgy.
1875–78	RANDS, WILLIAM H. -	Mining and Metallurgy.
1877–80	REEKS, TRENHAM HOWARD	Metallurgy.
1866–70	RENWICK, HENRY J. GREEN	Mining.
1864–67	RICHARDS, EDWARD -	Metallurgy.

Session.	Name.	Division.
1861–65	ROBERTS, WM. CHANDLER	Metallurgy.
1863–66	ROWDEN, W. T.	Mining and Metallurgy.
1871–74	SAISE, WALTER	Mining, Metallurgy and Geology.
1877–79	SALAMON, A. GORDON	Metallurgy.
1875–78	SAWYER, ARTHUR R.	Geology and Mining.
1877–80	SCOTT, RALPH G.	Mining and Metallurgy.
1872–75	SEYMOUR, GEORGE	Mining.
1878–81	SHANNON, ARTHUR	Metallurgy.
1876–81	SMITH, F. P.	Metallurgy.
1871–73	SMITH, GEORGE	Geology.
1864–67	SNELUS, GEORGE	Mining and Metallurgy.
1867–70	SOLLAS, W. JOHNSON	Geology.
1876–79	STATTER, H. B.	Mining.
1876–79	STRICKLAND, H.	Mining.
1876–78	SYED, ALI	Geology.
1867–68	TANNER, H. W. LLOYD	Geology.
1860–63	TAWNEY, EDWARD B.	Mining and Geology.
1863–66 and 1868–69	TAYLOR, H. CUMBERLAND	Metallurgy.
1871–74 and 1878–80	TAYLOR, JAMES	Metallurgy.
1874–78	TERRERO, MANUEL M.	Geology.
1855–57	THORNTON, RICHARD	Mining and Metallurgy.
1872–76 and 1879–80	TREDCROFT, H. E.	Mining.
1874–77	VOELCKER, EDWARD W.	Mining and Metallurgy.
1853–55	WALL, GEORGE P.	Mining, Metallurgy, and Geology.
1861–64	WARD, J. CLIFTON	Geology.
1872–76	WARD, WILLIAM F.	Metallurgy.
1864–67	WATSON, DAVID	Metallurgy and Geology.
1870–73	WESTMORELAND, JAMES WM.	Metallurgy.
1855–58	WESTON, WILLIAM	Metallurgy and Geology.
1859–62	WILKINSON, CLEMENT	Mining, Metallurgy, and Geology.
1878–81	WILKINSON, JOHN F.	Metallurgy.
1872–75	WILLIS, AMBROSE R.	Mining, Metallurgy, and Geology.
1857–59	WOOD, CHARLES S.	Mining and Geology.
1872–75	YOUNG, LAMONT H. G.	Mining.

Associates of the Royal College of Science with which is incorporated the Royal School of Mines.

Session.	Name.	Division.
1895–99	AARONS, JULIAN BOYD -	Mining (2nd Class). Metallurgy (2nd Class).
1889–95	ACKROYD, FRANK -	Mining (2nd Class). Geology (2nd Class).
1889–92	ADAMS, ROBERT - -	Agriculture (1st Class).
1886–90	ADAMSON, ARTHUR -	Physics (1st Class). Mechanics (1st Class).
1895–98	ADLER, HENRY GEORGE VERGOTTINI.	Mining (1st Class).
1886–94	AJURIA, CARLOS DE -	Mining (2nd Class).
1896–98 1899–00 1902–03	ALABASTER, RUPERT CECIL	Metallurgy (1st Class).
1899–02	ALEXANDER, ARCHIBALD DOUGLAS.	Mechanics (1st Class).
1893–96	ALLEN, ARTHUR ORMISTON	Physics (1st Class).
1891–94	ALLEN, FREDERICK JOHN -	Chemistry (2nd Class).
1884–88	ALLINGHAM, SIDNEY -	Metallurgy (2nd Class). Mining (1st Class).
1897–00	AMOR, JOSEPH - -	Mechanics (1st Class).
1884–88	ANDERSON, HERBERT -	Chemistry (2nd Class). Physics (2nd Class).
1896–00	ANDREWS, SAMUEL -	Chemistry (1st Class).
1898–01	ANTOINE, ADOLPHUS MYDDELTON.	Mining (2nd Class).
1891–94	ARCHER, RALPH MELVILLE	Physics (2nd Class).
1890–93	ARMSTRONG, FREDERICK WILLIAM.	Mining (1st Class). Metallurgy (2nd Class).
1896–99	ARNOLD, FRANK WILLIAM	Mechanics (1st Class).
1884–88	ASANO, NAGAYUKI -	Geology (2nd Class).
1886–89	ASHER-ARON, SAMUEL B. -	Metallurgy (1st Class).
1890–93 and 1897–98	ASHMORE, GEORGE PERCY	Mining (1st Class).
1886–88	ATKINS, HENRY C. -	Metallurgy (2nd Class).
1891–95	ATTENBOROUGH, LEONARD GEORGE.	Chemistry (2nd Class). Metallurgy 1st Class).
1899–00 1901–03	ATTWELL, HERBERT MOORE	Chemistry (2nd Class).
1881–84	AUDLEY, JAMES A. -	Biology (2nd Class). Geology (2nd Class).
1895–98	BAILEY, HERBERT -	Mining (2nd Class).
1898–01	BAIRSTOW, LEONARD -	Mechanics (1st Class).
1892–96	BAKER, FREDERICK JAMES	Agriculture (1st Class).

Session.	Name.	Division.
1900–03	BAKER, HAROLD EDWARD	Mining (2nd Class).
1901–02	BALL, EDWIN JENNINGS	Metallurgy (1st Class).
1891–94	BALL, JOHN	Mining (1st Class).
1897–01	BANDULSKA, HELENA	Biology (Botany, 1st Class). Chemistry (2nd Class).
1896–01	BANNISTER, CHARLES OLDEN.	Metallurgy (1st Class). ,, (Honours).
1884–87	BARBOUR, HUGH	Metallurgy (2nd Class).
1895–98	BARKER, JOHN WILLIAM	Physics (1st Class).
1893–97	BARLOW, ALFRED WILLIAM	Mining (2nd Class).
1878–82	BARNETT, FRANCIS T.	Metallurgy (2nd Class).
1889–93	BARNETT, ROBERT EDWARD	Chemistry (1st Class).
1887–95	BARRON, THOMAS	Biology (Zoology, 2nd Class), Geology (1st Class with Honours).
1898–01	BARTLETT, ROBERT JOHN	Chemistry (1st Class).
1896–99	BATEMAN, HENRY BERTRAM.	Mining (1st Class).
1899–02	BAYLEY, REGINALD FRANCIS GORDON.	Metallurgy (2nd Class).
1891–94	BAXANDALL, DAVID	Mechanics (1st Class).
1884–87	BAXANDALL, FRANK E.	Mechanics (1st Class).
1892–95	BAXTER, CECIL ALWYNE SELPRAM.	Mechanics (1st Class).
1885–88	BECKWITH, JOHN M.	Mining (1st Class).
1888–91	BECKWITH, LEONARD H.	Mining (2nd Class).
1890–93	BEDFORD, THOMAS TAYLOR	Mining (1st Class).
1884–87	BELCHER, FRANK	Chemistry (2nd Class).
1884–87	BELLO, CÆSAR	Mining (2nd Class).
1895–98	BENNETT, WILLIAM	Physics (1st Class).
1889–94	BENSUSAN, ARTHUR J.	Metallurgy (1st Class). Mining (1st Class).
1898–03	BENSUSAN, FERDINAND LEVI.	Mining (2nd Class).
1892–96	BIGGS, GEORGE HERBERT	Metallurgy (2nd Class). Mining (2nd Class).
1899–02	BINDER, JOHN HERMAN	Chemistry (1st Class).
1889–92	BISSET, JOSEPH	Agriculture (2nd Class).
1893–97	BLACK, HARRY CHARLES CAMPBELL.	Mining (2nd Class).
1885–88	BLACKMORE, WILLIAM	Metallurgy (1st Class).
1893–96	BLAKE, GEORGE STANFIELD	Metallurgy (2nd Class).
1888–91	BOLTON, HENRY T.	Metallurgy (2nd Class).
1884–86	BOODLE, LEONARD A.	Biology (1st Class).
1892–95	BORLAND, HUGH ALEXANDER MILLER.	Chemistry (1st Class).
1896–99	BORROW, FRANK KENDALL	Mining (1st Class).

Session.	Name.	Division.
1881–84	BOSWORTH-SMITH, PERCY	Metallurgy (1st Class)
1898–01	BOTSFORD, ROBERT SIMPSON	Mining (2nd Class).
1886–89	BOULTON, WILLIAM -	Geology (1st Class).
1890–95	BOURKE, HENRY WALLER LAURIE MCWILLIAM -	Metallurgy (1st Class). Mining (2nd Class). Geology (2nd Class).
1884–88	BOWER, WILLIAM R. -	Chemistry (2nd Class).
1893–96	BRADLEY, WILLIAM ALOYSIUS.	Chemistry (2nd Class).
1900–03	BRADSHAW, CHARLES CRAWFORD	Mining (2nd Class).
1899–02	BRADSHAW, HERBERT EDWARD	Mining (2nd Class).
1888–91	BRELICH, HENRY - -	Mining (2nd Class).
1894–98	BRETT, ALFRED JEAFFRESON	Chemistry (2nd Class). Metallurgy (1st Class).
1900–03	BRIGGS, HENRY - -	Mining (1st Class).
1886–89	BRISCOE, ALBERT E. -	Physics (1st Class with Honours).
1900–03	BROADWATER, CHARLES CHUMASERO	Mining (2nd Class).
1894–97	BRODIGAN, CHARLES BERNARD.	Mining (1st Class).
1888–91	BROOKS, FREDERICK ST. V.	Mining (2nd Class).
1884–86	BROOKS, JAMES F. -	Mining (2nd Class).
1897–00	BROOM, GEORGE HENRY -	Physics (1st Class).
1900–03	BROOME, LEONARD REEVES	Mechanics (2nd Class).
1894–98	BROUSSON, FREDERICK -	Mining (2nd Class). Metallurgy (1st Class).
1897–00	BROWNE, DONALD JAMES -	Metallurgy (2nd Class).
1890–95	BROWN, GERALD NOEL -	Chemistry (2nd Class). Metallurgy (2nd Class).
1897–00	BROWN, JOHN ABERCROMBY	Physics (1st Class).
1891–93	BRUCE, JAMES - -	Chemistry (1st Class).
1889–95	BRYANT, CECIL MOXON -	Mining (2nd Class).
1893–96	BUCHAM, WILLIAM -	Physics (2nd Class).
1886–89	BUCHANAN, WILLIAM -	Mechanics (1st Class).
1884–88	BUDGETT, HENRY B. -	Mining (2nd Class).
1886–89	BURBIDGE, WILLIAM G. -	Physics (2nd Class).
1886–89	BURGE, PERCY F. - -	Chemistry (2nd Class).
1900–03	BURROW, SIDNEY GEORGE	Physics (1st Class).
1894–97	BURROWS, HARRY -	Chemistry (1st Class).
1888–91	BUSBRIDGE, HAROLD -	Mechanics (1st Class).
1888–91	BUSCH, GUSTAVE E. -	Metallurgy (2nd Class). Mining (2nd Class).
1891–95	BUTCHER, HERBERT THOMAS	Mining (2nd Class).
1887–90	BUTEFISCH, THEODOR A. -	Mining (1st Class).
1888–91	BUTLER, ARTHUR G. -	Biology (Zoology, 2nd Class).

Session.	Name.	Division.
1890–93	BUTLER, CHARLES PRITCHARD.	Physics (2nd Class).
1893–96	BUTTERS, JOSEPH BENDALL	Chemistry (1st Class).
1894–97	BUTTON, JOHN WILLIAM -	Mechanics (2nd Class)— Physics (1st Class).
1890–93	BYRDE, FREDERICK T. -	Mining (2nd Class).
1897–00	BYWATERS, HUBERT WILLIAM.	Chemistry (1st Class).
1893–96	CABENA, RICHARD HANSON	Mechanics (2nd Class)-
1900–03	CAHEN, EDWARD - -	Chemistry (2nd Class)-
1885–96	CALVERT, SARA AGNES -	Biology (Botany, 1st Class).
1895–98	CAMERON, WILLIAM	Physics (1st Class).
1897–01	CAPSEY, HAROLD VINCENT	Chemistry (2nd Class).
1884–87	CARD, GEORGE W. -	Metallurgy (2nd Class), Geology (1st Class).
1885–88	CAREY, FREDERICK C. -	Chemistry (2nd Class).
1896–00	CARPENTER, DAVID JOSIAH	Geology (1st Class).
1882–85	CARR, PERCY E. O. -	Metallurgy (1st Class).
1884–87	CARRODUS, FREDERICK -	Chemistry (2nd Class).
1899–02	CARROLL, CHAS. MICHAEL-	Mining (2nd Class).
1891–94	CARTWRIGHT, HUBERT -	Metallurgy (2nd Class).
1891–94	CATHERALL, EZRA -	Chemistry (1st Class).
1884–87	CATTERMOLE, ARTHUR E.	Metallurgy (1st Class).
1888–91	CAVENDISH, HARRY -	Mining (2nd Class).
1897–00	CAVERS, FRANK - -	Biology (Botany, 1st Class).
1879–82	CEPERO, FRANCIS L. -	Mining (2nd Class).
1885–88	CHALMERS, JOHN A. -	Mining (1st Class).
1880–84	CHANEY, HARRY J. -	Metallurgy (1st Class).
1888–91	CHAMBERS, THEODORE G.	Mining (1st Class).
1898–01	CHANDLER, STAFFORD EDWIN.	Biology (Botany, 1st Class).
1896–99	CHAPMAN, FLORA -	Biology (Botany, 2nd Class).
1887–91	CLARK, ERNEST V. -	Chemistry (1st Class), Metallurgy (2nd Class).
1890–93	CLARK, HERBERT A. -	Mechanics (1st Class).
1884–86	CLARK, JAMES - -	Biology (1st Class).
1893–96	CLARK, JAMES - -	Agriculture (2nd Class).
1898–01	CLARKE, FREDERICK CHAS.	Physics (2nd Class).
1899–02	CLARKE, WILFRED HARRY	Physics (1st Class).
1895–98	CLARKE, GEORGE ERNEST	Physics (2nd Class).
1898–01	CLARKE, WILLIAM ELIJAH	Biology (Zoology, 2nd Class).
1885–88	CLARKSON, THOMAS -	Metallurgy (1st Class).
1893–96	CLEMENTS, HENRY HAMILTON.	Physics (2nd Class).

Session.	Name.	Division.
1892–96	CLIFFORD, EDWARD HERBERT.	Metallurgy (2nd Class), Mining (2nd Class).
1895–98	CLOUGH, WILLIAM THOMAS	Physics (1st Class).
1890–93	COGILL, FRANK - -	Mining (2nd Class).
1887–90	COKER, ERNEST G. -	Mechanics (1st Class).
1880–83	COLLINS, HENRY F. -	Mining (1st Class).
1898–00	CONDER, HARTWELL -	Mining (2nd Class).
1883–87	COOKE, ARTHUR M. M. -	Metallurgy (2nd Class). Mining (1st Class).
1889–92	COOKE, LEWIS H. -	Metallurgy (2nd Class). Mining (1st Class).
1896–00	COOM, HENRY - -	Metallurgy (1st Class). Mining (2nd Class).
1900–03	COOPER, JAMES PERCY CARRÉ	Mining (2nd Class).
1897–01	COOPER, WILLIAM - -	Metallurgy (1st Class).
1900–03	CORMACK, ROBERT RICHARDSON	Metallurgy (2nd Class).
1897–00	COULDREY, PAUL SIDNEY	Mining (2nd Class). Metallurgy (2nd Class).
1885–88	COULTAS, PHILIP C. -	Physics (2nd Class).
1895–99	COURTMAN, ERNEST OWEN	Metallurgy (1st Class), Mining (2nd Class).
1899–02	COURTNEY, REGINALD SYDNEY	Mining (2nd Class).
1894–97	COX, ARTHUR SAMBELL -	Physics (2nd Class).
1888–92	COWELL, ERNEST -	Mining (2nd Class).
1890–93	CRABTREE, HENRY -	Agriculture (1st Class).
1888–91	CRABTREE, JOHN D. -	Metallurgy (2nd Class).
1899–03	CRABTREE, JOHN HENRY	Chemistry (2nd Class).
1885–88	CRESWELL, FREDERICK H. P.	Mining (1st Class).
1896–99	CRESSWELL, JOHN -	Mining (1st Class).
1889–92	CROCKER, WALTER S. -	Chemistry (2nd Class).
1891–94	CROSS, CHARLIE RICHMOND	Biology (Zoology, 1st Class).
1898–99	CROWDER, HEDLEY -	Metallurgy (2nd Class).
1893–96	CROWTHER, JOE - -	Metallurgy (1st Class).
1887–91	CRUM, JAMES R. - -	Mining (1st Class). Metallurgy (2nd Class).
1892–95	CULLEN, HAROLD RIGBY -	Mechanics (1st Class). Physics (1st Class).
1894–98	CUNNINGTON, WILLIAM ALFRED.	Biology (Zoology, 2nd Class).
1890–93	CURRIE, WILLIAM MACGREGOR.	Mining (2nd Class).
1900–03	DAVID, LOUIS WILLIAM JULIUS	Metallurgy (1st Class).

Session.	Name.	Division.
1893–96	DAVIDGE, HENRY THOMAS	Physics (1st Class), Mechanics (1st Class).
1884–91	DAVIES, ARTHUR M.	Biology (1st Class). Geology (1st Class).
1889–92	DAW, FREDERIC W.	Chemistry (2nd Class).
1890–95	DAWSON, THOMAS LAUNCELOT.	Mining (2nd Class).
1879–82	DAY, ALBERT W.	Mining (1st Class).
1890–93	DAY, WILLIAM	Metallurgy (1st Class).
1894–97	DEAN, HARRY	Metallurgy (2nd Class).
1900–03	DE CHAZAL, EDMOND MARC	Mining (2nd Class).
1888–91	DEL MAR, ALGERNON P.	Mining (1st Class).
1889–92	DICKINSON, ARTHUR	Mining (2nd Class).
1885–88	DIETZSCH, FERDINAND F. L.	Mining (2nd Class).
1895–98	DITCHBURN, WILLIAM	Physics (1st Class).
1879–82	DIVETT, GEORGE ROSS	Geology and Mining (1st Class).
1894–97	DIXON, ERNEST EDWARD LESLIE.	Geology (1st Class).
1899–00		Stratigraphical Geology (Honours).
1889–94	DIXON, WILLIAM	Metallurgy (2nd Class), Mining (2nd Class).
1898–03	DOBBIE, JAMES	Mechanics (2nd Class).
1891–96	DODD, HARVEY	Metallurgy (2nd Class), Mining (2nd Class).
1893–97	DOUGLAS, EDWARD ALISON	Mining (2nd Class), Metallurgy (2nd Class).
1882–85	DOWDEN, WALTER A. A.	Metallurgy (2nd Class).
1890–93	DOWLING, JOHN	Mechanics (2nd Class). Class).
1899–03	DRABBLE, ERIC	Biology (Botany, 1st Class and Honours).
1899–02	DRAKE - BROCKMAN, EDWARD	Metallurgy (2nd Class).
1888–92	DREW, WALTER N.	Mining (2nd Class).
1900–03	DU FAUR, JOHN BERTRAM	Mining (2nd Class).
1899–02	DUDGEON, WILLIAM FRANCIS HENLEY	Mining (2nd Class).
1885–89	DUERDEN, JAMES E.	Biology (Zoology, 2nd Class).
1894–97	DUNCAN, ROBERT HENRY HOWARD.	Mechanics (2nd Class).
1894–99	DUNCANSON, JAMES	Mining (2nd Class).
1892–99	DUNKERLEY, GEORGE DIXON	Chemistry (2nd Class). Geology (1st Class).
1898–01	DUNN, STANLEY CHARLES	Mining (1st Class).
1890–93	DUTTON, FREDERICK V.	Agriculture (2nd Class).
1895–99	DYER, SYDNEY CHARLES	Mining (2nd Class).

Session.	Name.	Division.
1885–88	DYMOND, ARTHUR W.	Mining (1st Class).
1893–96	EAGLES, JAMES	Mechanics (1st Class).
1900–03	EASTAUGH, FREDERICK ALLDIS	Metallurgy (1st Class).
1894–97	ECCLES, WILLIAM HENRY	Physics (1st Class).
1896–99	EDDOWES, HUGH MORTIMER	Mining (2nd Class).
1894–97	EDMED, FRANK GEORGE	Chemistry (1st Class).
1890–92	EDSER, EDWIN	Physics (1st Class).
1896–99	EDWARDS, ERNEST WILLIAM JOHN	Mechanics (1st Class).
1886–90	EDWARDS, WILLIAM B. D.	Geology (1st Class).
1886–92	ELLIS, THOMAS F.	Chemistry (2nd Class), Mining (2nd Class).
1894–97	ELWES, HUGH GEOFFREY	Metallurgy (2nd Class).
1888–91	EUSTICE, JOHN	Metallurgy (1st Class).
1886–89	EVERETT, SYDNEY E.	Mining (1st Class).
1896–00	FAIRBAIRN, ALAN JOHN	Mining (2nd Class).
1896–01	FANE, HERBERT WILLIAM	Mining (2nd Class).
1899–02	FANTHAM, HAROLD BENJAMIN.	Chemistry (2nd Class). Zoology (1st Class).
1886–90	FARQUHARSON, CHARLES R.	Mining (2nd Class).
1891–94	FEARNLEY, GEORGE WILLIAM.	Mechanics (1st Class).
1890–93	FEILDING, ROWLAND CHA.	Mining (2nd Class).
1899–02	FENNELL, JOHN HOWARD	Mining (2nd Class).
1896–99	FENWICK, GEORGE JOHN	Chemistry (1st Class).
1892–95	FERGUSON, REGINALD WILLIAMS	Chemistry (2nd Class).
1889–92	FERGUSON, WILLIAM D.	Mining (2nd Class).
1891–94	FERGUSSON, MALCOLM	Mining (2nd Class).
1898–01	FERMOR LEWIS LEIGH	Metallurgy (1st Class).
1895–98	FIELD, SAMUEL	Chemistry (1st Class).
1892–95	FINCH, HENEAGE WYNNE	Mining (1st Class).
1890–93	FISHER, EDWARD BUCKINGHAM.	Metallurgy (2nd Class).
1894–98	FISHER, FRANK	Mechanics (1st Class).
1899–02	FLETCHER, STANLEY EDGINGTON.	Mining (2nd Class).
1888–91	FORD, STANLEY H.	Metallurgy (2nd Class).
1892–95	FORSYTH, ROBERT WILLIAM	Physics (1st Class).
1898–01	FORWARD, ERNEST ALFRED	Mechanics (1st Class).
1893–96	FOULDS, JAMES	Geology (2nd Class).
1889–93	FOURNIER D'ALBE, EDMUND E.	Physics (2nd Class).
1882–85	FOWLER, ALFRED	Mechanics (1st Class).
1896–00	FOX, ALFRED	Mining (1st Class). Metallurgy (1st Class).
1891–94	FRAMPTON, NAPIER PAUL	Mining (2nd Class).

Session.	Name.	Division.
1884–87	FRANCHY, ANDRES - -	Mining (2nd Class).
1899–00	FRANCIS, JOHN LANGHORNE	Mining (2nd Class).
1895–99	FRANCK, LUTHER CYRIL -	Metallurgy (2nd Class), Mining (2nd Class).
1891–96	FRANCO, SANTIAGO FELIPE	Mining (2nd Class).
1888–91	FRASER, THOMAS S. - -	Metallurgy (2nd Class).
1890–92	FREEMAN, OLIVER - -	Physics (2nd Class).
1892–95	FREEMAN, WILLIAM GEORGE	Biology (Botany, 1st Class).
1881–84	FREMERSDORF, WILLIAM F.	Metallurgy (2nd Class).
1898–01	GARLAND, ARTHUR EDWARD	Chemistry (1st Class).
1890–94	GIBB, ALLAN - - -	Metallurgy (1st Class with Honours).
1898–01	GIBSON, WILLIAM THOMAS	Biology (Zoology, 2nd Class).
1886–89	GILBERT, JOHN W. - -	Chemistry (1st Class).
1898–01	GILLESPIE, ROBERT - -	Chemistry (1st Class).
1895–99	GILMAN, ELLIS PHILIP -	Metallurgy (2nd Class), Mining (2nd Class).
1884–87	GILMOUR, JAMES A. - -	Metallurgy (1st Class).
1900–03	GLOVER, FRANK ERNEST -	Physics (2nd Class).
1899–02	GOODCHILD, WILLIAM HENRY	Metallurgy (1st Class).
1899–02	GOODSON, HOWARD ERNEST	Chemistry (2nd Class).
1895–98	GOODYEAR, CHARLES ERNEST.	Mechanics (1st Class). Physics (1st Class).
1899–02	GORDON, ALEXANDER WILLIAM	Mining (2nd Class).
1897–02	GORDON, JOHN THOMAS	Metallurgy (2nd Class).
1896–02	GOUGH, GEORGE CECIL -	Zoology (1st Class). Geology (1st Class).
1888–91	GOUGH, GEORGE H. - -	Mining (2nd Class).
1897–00	GOWAN, GEORGE, D'OLIER	Mining (2nd Class).
1898–02	GOW, KENNETH - -	Mining (2nd Class).
1897–00	GOW, WILLIAM JAMES -	Mechanics (1st Class). Physics (2nd Class).
1885–88	GRACE, GEORGE - -	Chemistry (2nd Class).
1898–01	GRAHAM, JOHN FREDERICK	Mining (1st Class).
1884–87	GRANT, JOHN H. - -	Mining (2nd Class).
1881–85	GRAVES, HENRY G. -	Metallurgy (1st Class). Mining (1st Class).
1891–94	GRAY, CHARLES JOSEPH -	Mining (1st Class).
1896–99	GRAY, GEORGE WYNTER	Mining (2nd Class).
1900–03	GRAY, HAROLD JAMES -	Chemistry (2nd Class).
1885–88	GRAY, PHILIP L. - -	Physics (1st Class).
1889–92	GREAVES, JOSEPH - -	Mining (2nd Class).
1900–03	GREEN, GEORGE HERBERT	Chemistry (1st Class).
1879–82	GREEN, JOHN E. - -	Metallurgy (2nd Class).

Session.	Name.	Division.
1892–95	GREEN, JOHN JAMES	Chemistry (1st Class).
1889–92	GREEN, LEONARD M.	Metallurgy (2nd Class).
1891–94	GREENWOOD, SARAH CLOUGH.	Geology (2nd Class).
1889–91	GREEVES, ALFRED	Chemistry (1st Class).
1897–01	GREIG, GORDON EASTLEY	Mining (2nd Class).
1884–87	GRIFFITHS, ALBERT	Mechanics (1st Class).
1884–87	GRIFFITHS, ANDRÉ P.	Metallurgy (1st Class).
1887–90	GRIFFITHS, HARRY D.	Mining (1st Class).
1898–00	GRIFFITHS, WILLIAM THOMAS.	Mining (1st Class).
1890–93	GRIGOR, JAMES	Mechanics (2nd Class).
1888–91	GRIME, HERBERT	Chemistry (1st Class).
1889–94	GRIMES, GEORGE ERNEST	Metallurgy (2nd Class), Mining (2nd Class), Geology (2nd Class).
1888–93	GROSSMANN, EDWARD	Chemistry (2nd Class).
1888–92	GRUBB, WALTER C.	Mining (2nd Class).
1896–99	GUNDRY, PHILIP GEORGE	Physics (1st Class).
1898–02	GWINNELL, RUSSELL FROST	Geology (1st Class).
1885–88	HADLEY, HARRY E.	Physics (1st Class).
1889–92	HAGERTY, ELIZABETH G.	Chemistry (2nd Class).
1897–00	HALL, ALBERT	Mechanics (1st Class).
1894–97	HALL, WILLIAM GERARD	Physics (2nd Class).
1895–98	HALLIDAY, HERBERT	Physics (1st Class).
1883–87	HAMILTON-GORDON, ERNEST A.	Mechanics (1st Class).
1885–88	HAMLEY, WILLIAM F.	Mining (2nd Class).
1898–01	HAMMOND, EDGAR WILLIAM	Mining (2nd Class).
1897–00	HAMPSHIRE, PERCY MARSON	Physics (2nd Class).
1896–99	HANDY, CHARLES EDWARD	Mechanics (2nd Class).
1897–00	HANDLEY, HERBERT JOSHUA	Chemistry (1st Class).
1879–82	HARBORD, FREDERICK W.	Metallurgy (1st Class).
1885–88	HARDY, FRANCIS J.	Chemistry (2nd Class).
1896–99	HARPER, HARRY	Chemistry (1st Class).
1890–93	HARRIS, HARRY	Metallurgy (2nd Class).
1895–98	HARRISON, ERNEST THOMAS	Physics (1st Class).
1892–95	HARRISON, FRANCIS CHAMBERS.	Chemistry (1st Class).
1894–97	HARRISON, HERBERT SPENCER.	Biology (Zoology, 1st Class).
1888–95	HARRISON, JAMES	Biology (Zoology, 1st Class). Geology (1st Class).
1891–94	HARRISON, JOHN ANSTEAD	Chemistry (2nd Class).
1889–92	HARRISON, WALTER E.	Physics (2nd Class).
1880–83	HART, THOMAS G.	Mining (2nd Class).
1895–98	HART-SMITH, JAMES	Chemistry (2nd Class).

Session.	Name.	Division.
1891–95	HATHAWAY, HERBERT GINGER.	Chemistry (2nd Class).
1890–93	HAWKINS, ROBERT SPENCER	Mining (2nd Class).
1898–01	HAY ERROL GORDON -	Mining (2nd Class).
1891–92	HAYTON JOHN W. P.	Physics (1st Class).
1892–97	HEAL, JOHN HARRIS -	Metallurgy (1st Class) Mining (2nd Class).
1881–86	HEALEY, ELIZABETH- -	Chemistry (1st Class). Biology (2nd Class).
1891–94	HEMBROUGH, JAMES -	Chemistry (2nd Class).
1897–00	HENLEY, ETHEL - -	Botany (2nd Class).
1898–02	HENNIKER, CHARLES HENRY.	Metallurgy (2nd Class).
1899–02	HENNIKER, GERALD -	Metallurgy (2nd Class).
1896–99	HEWITT, WILLIAM HENRY	Chemistry (2nd Class).
1884–87	HEWITT, JOHN T. - -	Chemistry (1st Class).
1892–95	HEWSON, WALTER - -	Physics (2nd Class).
1885–88	HEY, HAROLD E. - -	Chemistry (1st Class).
1895–98 1899–00	HIBBERT, ERNEST -	Physics (2nd Class). Mining (2nd Class).
1893–96	HICKINBOTHAM, HENRY CHARLES.	Chemistry (2nd Class).
1899–02	HIGGINGS, ARTHUR HOWARD.	Metallurgy (1st Class).
1886–89	HIGHFIELD, EDMUND G. -	Physics (2nd Class).
1895–98	HILL, THOMAS GEORGE -	Biology (Botany, 1st Class).
1893–96	HINCHLEY, JOHN WILLIAM	Metallurgy (1st Class).
1892–97	HINKS, PERCY JOHN -	Chemistry (2nd Class).
1891–96	HINTON, HENRY ARTHUR -	Metallurgy (2nd Class). Mining (2nd Class), Geology (1st Class).
1886–89	HOLBECHE, HENRY- -	Physics (2nd Class).
1898–99	HOLIDAY, FRANCIS AUGUSTUS.	Geology (2nd Class).
1885–88	HOLLAND, THOMAS H. -	Geology (1st Class).
1881–84	HOLLOWAY, GEORGE T. -	Chemistry (1st Class).
1884–86	HOLMES, GEORGE G. -	Mining (1st Class).
1894–98 1899–00	HOLMES, WILLIAM FREDERICK.	Geology (2nd Class). Mining (2nd Class).
1897–01	HOOPER, JAMES GEORGE -	Mining (2nd Class).
1884–88	HOPE, EDMUND L. - -	Mining (1st Class).
1880–83	HOPKINS, ARTHUR W. -	Metallurgy (2nd Class).
1887–91	HOPKINS, HERBERT W. -	Metallurgy (2nd Class).
1896–00	HOPWOOD, ARTHUR - -	Physics (2nd Class).
1894–97	HORA, FREDERICK RUDOLPH.	Chemistry (1st Class).
1897–01	HORSLEY, EDWARD CECIL	Mechanics (1st Class).

Session.	Name.	Division.
1899–02	HORSLEY, JOHN REGINALD	Mining (1st Class).
1897–00	HORWOOD, CUTHBERT BARING.	Mining (2nd Class).
1886–90	HOTSON, WILLIAM E.	Mining (2nd Class).
1898-02	HOUNSFIELD, LESLIE HAYWOOD.	Mechanics (2nd Class).
1896–98	HOW, EDITH PHYLLIS	Physics (2nd Class).
1893–96	HOWARD, ALBERT	Chemistry (1st Class).
1881–84	HOWARD, ALFRED	Physics (1st Class).
		Metallurgy (2nd Class).
1888–91	HOWE, BEN	Mining (2nd Class).
1901–03	HUDDART, LINDOW HEREWARD LEOFRIC.	Mining (2nd Class).
1897–00	HUDSON, OSWALD FREEMAN	Chemistry (2nd Class).
1893–96	HUGHES, ARTHUR JAMES	Metallurgy (2nd Class).
1881–84	HUGHES, HERBERT W.	Mining (1st Class).
1896–99	HUGHES, PERCY	Chemistry (2nd Class).
1880–83	HUGHES, THEOPHILUS VAUGHAN	Mining (2nd Class).
		Metallurgy (1st Class).
1895–98	HUGON, EDWARD CHARLES	Metallurgy (2nd Class).
1894–97	HUMBERSTONE, THOMAS LLOYD.	Chemistry (2nd Class).
1884–89	HUME, WILLIAM F.	Geology (1st Class).
		Metallurgy (2nd Class).
1885–89	HUNT, BERNARD	Mining (2nd Class).
1893–96	HUNTER, THOMAS GILBERT	Mining (2nd Class).
1887–90	HUNTLEY, GEORGE N.	Chemistry (1st Class with Honours).
1892–95	HUTCHIN, HENRY WILLIAM	Chemistry (1st Class).
1894–96	HYNE, ARTHUR EDWARD	Mechanics (1st Class).
1875–82	I'ANSON, FRANK C.	Mining (2nd Class).
1881–84	ILLINGWORTH, BENJAMIN	Physics (1st Class).
1893–96	IVEY, JOSEPH HENRY	Metallurgy (1st Class).
1895–98	JACKSON, HARRY	Mechanics (1st Class).
		Metallurgy (1st Class).
1886–89	JACKSON, SAMUEL	Chemistry (2nd Class).
1891–94	JACKSON, WILLIE	Chemistry (2nd Class).
1897–00	JAMES, GILBERT ERNEST	Physics (2nd Class).
1895–98	JAMES, HUGH WILLIAM	Chemistry (2nd Class).
1896–99	JAMES, WILLIAM HENRY NICHOLS.	Physics (2nd Class).
1895–99	JAMESON, JOHN JULIUS IRVINE.	Mining (2nd Class)
1887–90	JAQUET, JOHN B.	Mining (1st Class).
1894–97	JARMAN, ARTHUR	Metallurgy (1st Class).
1899–01 1902–03	JARRARD, WILLIAM JOHN	Chemistry (1st Class).

Session.	Name.	Division.
1887–90	JARRATT, WILLIAM S. -	Physics (2nd Class).
1889–92	JEANS, HAROLD - -	Metallurgy (1st Class).
1888–91	JEFFERSON, JOSEPH -	Metallurgy (1st Class).
1893–97	JEFFERY, JACK LANE -	Mining (2nd Class).
1885–88	JENKINS, HENRY C. -	Metallurgy (1st Class).
1897–00	JENKINSON, ERNEST ARTHUR.	Chemistry (1st Class).
1901–03	JOHN, LLEWELYN - -	Biology (Botany, 1st Class).
1898–01	JOHNSON, OWEN - -	Metallurgy (1st Class). Mining (1st Class).
1888–92	JOHNSON, ROBERT R. -	Metallurgy (2nd Class).
1894–98	JONES, ARTHUR - -	Metallurgy (1st Class). Mining (2nd Class).
1889–95	JONES, EDGAR STRANGWAYS	Mining (2nd Class).
1887–90	JONES, HENRY E. -	Mining (2nd Class).
1900–03	JONES, HUBERT CECIL -	Mining (2nd Class).
1888–91	JONES, LIONEL M. -	Chemistry (1st Class).
1896–00	JONES, OWEN - -	Mining (2nd Class).
1891–94	JONES, THOMAS - -	Agriculture (1st Class).
1899–02	JORDAN FRANK WILFRED	Physics (1st Class).
1891–94	JORDAN-SMITH, BENJAMIN	Chemistry (2nd Class).
1895–98	JUSTICE, JAMES NORVAL -	Mining (2nd Class).
1879–83	KAMENSKY, GEORGE -	Metallurgy (1st Class). Mining (2nd Class).
1892–95	KAY, WILLIAM HEPPENSTALL.	Physics (2nd Class).
1892–98	KAYE, FREDERICK -	Chemistry (2nd Class).
1889–02	KAYE, GEORGE WILLIAM CLARKSON.	Physics (1st Class).
1897–00	KEELING, FREDERICK WILLIAM.	Chemistry (1st Class).
1885–88	KELSALL, WILLIAM -	Mechanics (1st Class).
1898–01	KELSEY, PERCY WILLIAM	Mechanics (2nd Class).
1889–92	KEMPER-VOSS, EBDEN -	Mining (2nd Class).
1896–99	KENYON, PERCY -	Mining (2nd Class).
1898–02	KERR, JAMES STEWART -	Chemistry (2nd Class).
1897–00	KERSEY, ALFRED THOMAS JOHN.	Mechanics (1st Class).
1900–03	KETT FREDERICK FARRINGTON.	Mining (2nd Class).
1890–94	KINLOCH, ARCHIBALD DAVID.	Mining (2nd Class).
1888–91	KIRKPATRICK - PICARD, HUGH F.	Metallurgy (2nd Class).
1886–89	KIRMAN, WALTER -	Chemistry (1st Class).
1888–91	KITTO, NONO - -	Mining (1st Class).

Session.	Name.	Division.
1890–96	KNOWLTON, ANNIE ROSE -	Biology (Botany, 2nd Class).
1889–92	LACE, FRANK D.	Metallurgy (2nd Class). Mining (1st Class).
1895–98	LACELL, HAROLD GEORGE	Chemistry (2nd Class).
1897–01	LAIRD, JOHN - -	Mining (2nd Class).
1899–02	LAMBERT, KENNETH NORMAN.	Mining (2nd Class).
1895–98	LAMB, SIDNEY ERNEST -	Physics (2nd Class). Mechanics (2nd Class).
1899–02	LANE, ALEXANDER LESLIE -	Metallurgy (1st Class).
1896–99	LARMUTH, ERNEST -	Mining (1st Class).
1894–02	LAW, EDWARD FULTON -	Metallurgy (2nd Class).
1886–91	LAWN, JAMES G. - -	Mining (1st Class).
1893–96	LAWS, BERNARD COURTNEY	Physics (2nd Class), Mechanics (2nd Class).
1887–90	LAWSON, JAMES C. E. -	Mining (2nd Class).
1896–99	LAY, DOUGLAS - -	Metallurgy (1st Class).
1893–96	LEA, FREDERICK CHARLES	Physics (1st Class), Mechanics (1st Class).
1900–03	LEACH, FREDERICK PEACOCK.	Chemistry (1st Class).
1900–03	LEADBETTER, HAROLD -	Chemistry (1st Class).
1898–01	LECKY, WILLIAM STANLEY	Metallurgy (1st Class).
1884–88	LEECHMAN, JOHN - -	Mining (1st Class).
1896–00	LEHMANN, ANDREW WILLIAM.	Metallurgy (2nd Class).
1888–91	LEITCH, ANGUS - -	Mechanics (2nd Class).
1896–01	LEVY, ERNEST - -	Mining (2nd Class).
1885–88	LEWIS, HENRY L. -	Mining (2nd Class).
1889–92	LEZARD, HERBERT -	Mining (2nd Class).
1885–88	LICHTENBURG, ERNEST -	Mining (1st Class).
1888–91	LISHMAN, ALFRED B. -	Physics (2nd Class).
1894–98	LISTER, JOHN - -	Mechanics (1st Class).
1895–98	LISTER, JOSEPH - -	Chemistry (1st Class).
1882–86	LITTLE, JOHN C. - -	Metallurgy (1st Class). Mining (1st Class).
1881–84	LOMAS, JOSEPH - -	Biology (2nd Class). Geology (2nd Class).
1890–92	LONGBOTTOM, JOHN G. -	Mechanics (1st Class).
1890–95	LONG-INNES, CLIVE SELWYN	Mining (2nd Class).
1892–98	LONGSHAW, WILLIAM -	Chemistry (1st Class), Physics (1st Class).
1896–00	LOUGH, VICTOR -	Physics (2nd Class).
1898–01	LOVERIDGE, ARTHUR WALTER.	Mechanics (2nd Class).
1897–01	LUCAS, GODFREY DAVEY -	Mining (2nd Class).

Session.	Name.	Division.
1891–95	LUCAS, PERCY WALTER -	Mining (2nd Class).
1899–02	LYONS, WILLIAM JOSEPH -	Physics (1st Class).
1896–99	LYON, UNA - -	Biology (Botany, 1st Class).
1896–01	MACALISTER, DONALD ALEXANDER.	Mining (2nd Class).
1884–88	MACANDREW, HAROLD -	Mining (2nd Class).
1900–03	MCCOMBIE, HAMILTON -	Chemistry (1st Class).
1889–92	MCCORMICK, SHEPHERD J.	Metallurgy (1st Class).
1898–03	MCDERMOTT, EDWARD DUFFIELD.	Mining (2nd Class).
1890–93	MACDONALD, DONALD JOHN	Mining (1st Class).
1893–96	MACDONALD, WILLIAM -	Metallurgy (2nd Class).
1885–89	MACDONALD, WILLIAM -	Chemistry (2nd Class). Metallurgy (1st Class).
1896–99	MCDOUGALL, ARCHIBALD	Physics (1st Class).
1896–99	MCEWEN, JAMES MELDRUM	Physics (1st Class).
1893–96	MCEWEN, SAMUEL	Metallurgy (1st Class).
1888–94	MACFARLANE, RIENZI WALTON.	Mining (2nd Class).
1895–99	MACKAY, ALEXANDER NEIL	Mining (2nd Class).
1890–93	MACKENZIE, KENNETH -	Mining (1st Class). Metallurgy (2nd Class).
1894–97	MCLELLAN, JOHN -	Mining (1st Class).
1885–88	MCMURTRY, GEORGE C. -	Chemistry (2nd Class). Metallurgy (1st Class).
1891–95	MCNEILL, HUGH COLLEY -	Metallurgy (2nd Class), Mining (2nd Class).
1885–88	MCNEILL, WILLIAM -	Metallurgy (1st Class).
1883–87	MCWILLIAM, ANDREW -	Metallurgy (1st Class).
1896–99	MADGWICK, THOMAS GEORGE.	Mining (1st Class).
1897–00	MAIR, FRANK ERNEST -	Mining (2nd Class).
1886–89	MALCOLMSON, JAMES W. -	Mining (2nd Class).
1895–98	MANN, HERBERT LESLIE -	Mechanics (2nd Class).
1891–95	MARIAS, BELFIELD -	Mining (2nd Class).
1893–96	MARKS, EDWARD SEABORN	Metallurgy (2nd Class).
1898–03	MARKS, OSCAR SIDNEY -	Metallurgy (2nd Class).
1886–91	MARRIOTT, HUGH F. -	Geology (2nd Class), Mining (2nd Class).
1891–94	MARSHALL, BOUCHER-MERVYN COLE.	Chemistry (1st Class).
1887–90	MARSHALL, GEOFFREY -	Mining (1st Class).
1900–03	MARTIN, CHARLES -	Mining (2nd Class).
1891–96	MARTINEAU, CARYL EDWARD.	Mining (2nd Class).
1893–96	MARTYN, HERBERT GEORGE	Physics (2nd Class).
1890–93	MARTYN, THOMAS G. -	Metallurgy (2nd Class).

Session.	Name.	Division.
1893–96	MASTERS, EDWARD -	Chemistry (2nd Class).
1893–96	MELDRUM, ANDREW NORMAN.	Chemistry (1st Class).
1890–93	MELLAND, GODFREY -	Metallurgy (1st Class), Mining (2nd Class).
1891–93	MELTON, GEORGE ROBERT	Physics (1st Class).
1896–99	MENNELL, JAMES LESLIE	Metallurgy (2nd Class).
1891–94	MERRETT, WILLIAM HENRY	Metallurgy (1st Class).
1884–86	MERRICKS, FRANK -	Mining (1st Class).
1893–96	METCALFE, ROBERT MUNKMAN.	Mechanics (2nd Class).
1894–97	MEYER, HANS SÖREN -	Mining (1st Class).
1895–99	MIDDLETON, HENRY MAXTON.	Mining (2nd Class).
1893–98	MICHAU, DANIEL - -	Mining (2nd Class).
1898–02	MICKLETHWAIT, FRANCES MARY GORE.	Chemistry (2nd Class).
1887–94	MILNE, HENRY BARNES -	Biology (Zoology, 2nd Class; Botany, 2nd Class).
1898–01	MONDY, ALBERT GEORGE -	Mining (2nd Class).
1888–91	MOORE, JOHN E. S. -	Biology (Zoology, 2nd Class).
1898–01	MORAY-BROWN, ORLANDO	Mining (2nd Class).
1892–95	MORE, ANDREW - -	Chemistry (2nd Class).
1894–96	MORGAN, GILBERT THOMAS	Chemistry (1st Class).
1899–03	MORRIS, EDWIN - -	Physics (2nd Class). Metallurgy (2nd Class).
1891–95	MORRIS, JAMES - -	Mining (2nd Class).
1892–96	MORRISON, CHRISTIAN ROBERTSON.	Metallurgy (2nd Class); Mining (2nd Class).
1891–95	MOULDEN, JOHN COLLETT	Mining (1st Class). Metallurgy (1st Class).
1897–00	MOULD, FRANK - -	Mechanics (1st Class).
1884–87	MOUSLEY, FRANK	Metallurgy (2nd Class).
1899–02	MOYLE, EDWARD CHARLES-	Mechanics (1st Class).
1891–98	MUDGE, GEORGE PERCIVAL	Biology (Zoology, 2nd Class), Geology (1st Class).
1893–96	MUIR, WILLIAM - -	Mining (2nd Class).
1890–93	MUNNIK, JOHN HENRY -	Mining (2nd Class).
1894–97	MUNTON, FREDERICK THOMAS.	Metallurgy (1st Class).
1900–03	NESBITT, COSBY THOMAS -	Mining (1st Class).
1894–98	NETTER, ALBERT JOHN -	Mining (2nd Class).
1893–96	NEWMAN, FRANK HERBERT	Chemistry (2nd Class).
1887–90	NEWSOME, TOM - -	Chemistry (2nd Class).

Session.	Name.	Division.
1892–95	NICHOLLS, ARTHUR -	Chemistry (1st Class).
1896–01	NICHOLLS, FRANK -	Mining (2nd Class).
1897–02	NICHOLLS, FRANK -	Mining (2nd Class).
1897–01	NICHOLLS, GEORGE EDWARD.	Biology (Botany, 2nd Class). Biology (Zoology, 2nd Class).
1890–94	NICHOLLS, HARRY ERNEST	Metallurgy (2nd Class). Mining (2nd Class).
1886–89	NICHOLS, HORACE G. -	Metallurgy (2nd Class).
1899–02	NICHOLSON, ARTHUR CLIVE	Mining (1st Class).
1900–03	NIGHTINGALE, ERNEST -	Mining (2nd Class).
1890–93	NITCH, HERBERT GEORGE -	Mining (1st Class).
1895–99	NIVEN, JOHN CROMKIE	Mining (2nd Class).
1892–95	NIXON, WILLIAM FREDERICK.	Mechanics (2nd Class).
1898–01	NORMAN, GEORCE MARSHALL.	Chemistry (1st Class).
1897–01	NORMAN, LIONEL - -	Mining (2nd Class).
1885–88	NORTH, BARKER - -	Chemistry (1st Class).
1897–00	ODELL, WILLIAM LOCKYER	Chemistry (2nd Class).
1900–01	OKE, ALFRED LIVINGSTONE	Mining (2nd Class).
1897–01	OLDFIELD, FRANCIS WILLIAM.	Chemistry (1st Class). Mining (2nd Class).
1899–02	ORSBORN, SARAH BEATRICE	Chemistry (2nd Class).
1900–03	O'SHAUGHNESSY, BERNARD	Chemistry (2nd Class).
1894–97	O'SHAUGHNESSY, FRANCIS RICHARD.	Chemistry (2nd Class).
1893–97	OUTHETT, CHRISTOPHER -	Chemistry (2nd Class).
1894–97	OVERTON, GEORGE LEONARD	Physics (2nd Class).
1898–02	OWTRAM, CYRIL LAURENCE	Mining (2nd Class).
1898–03	PAGE, JOHN JAMES ADDINGTON.	Mining (2nd Class), Metallurgy (2nd Class).
1891–94	PALMER HENRY GEORGE -	Mining (2nd Class).
1900–03	PAM, EDGAR - -	Mining (2nd Class).
1889–93	PARK, FRANCIS W. -	Metallurgy (2nd Class). Mining (2nd Class).
1898–02	PARKER, GEORGE EWART -	Metallurgy (2nd Class). Mining 2nd Class).
1889–92	PARKER, LLEWELLYN -	Metallurgy (2nd Class). Mining (1st Class).
1882–85	PARKINSON, FRANK B. -	Metallurgy (2nd Class).
1887–90	PARKINSON, THOMAS F. -	Mechanics (2nd Class).
1887–90	PARRISH, SAMUEL -	Chemistry (1st Class).
1890–93	PARRY, LAURENCE -	Metallurgy (1st Class).
1897–01	PASSOW, FREDERICK MALET	Mining (2nd Class).

Session.	Name.	Division.
1895–98	PATCHIN, GEORGE -	Metallurgy (1st Class).
1898–02	PATTERSON, PHILIP FRANCIS.	Mining (2nd Class).
1887–91	PAWLE, REGINALD -	Mining (2nd Class).
1890–93	PAYNE, ALBERT EDWARD -	Mining (1st Class). Metallurgy (2nd Class).
1889–93	PEAKE, WALTER C.	Metallurgy (2nd Class).
1893–96	PENN, FRANCIS RICHARD -	Chemistry (1st Class).
1883–86	PEREZ, VICTOR E. -	Metallurgy (2nd Class).
1889–92	PERRY, GEORGE H. -	Chemistry (1st Class).
1899–02	PERRY, PERCIVAL JOHN -	Mining (1st Class).
1889–92	PERRY, PERCY J. - -	Metallurgy (2nd Class).
1884–86	PETLEY, WILLIAM -	Metallurgy (2nd Class).
1891–94	PETTER, GUY BAZELEY -	Mechanics (2nd Class).
1879–82	PHILIP, ARNOLD -	Metallurgy (1st Class)
1896–99	PICKERING, WILLIAM -	Chemistry (1st Class).
1898–01	PICKLES, ARTHUR -	Geology (1st Class).
1890–91	PILL, ROBERT - -	Mining (1st Class).
1895–02	PIZEY, JAMES HENRY -	Chemistry (2nd Class).
1893–96	PLATT, WILLIAM NEWALL	Chemistry (2nd Class). Agriculture (2nd Class).
1890–93	PLEWMAN, GILBERT GEORGE	Mining (2nd Class).
1900–03	POMEROY, PHILIP SAMUEL	Chemistry (2nd Class).
1887–90	POOLE, FRANK C. - -	Metallurgy (1st Class).
1894–96	POORE, PHILIP - -	Mining (2nd Class)
1893–96	POWELL, ALBERT - -	Chemistry (2nd Class).
1879–82	POWELL, CHARLES H. -	Metallurgy (2nd Class).
1884–87	POWELL, JOHN H. -	Chemistry (1st Class).
1899–02	POWELL, WILLIAM HENRY	Mechanics (2nd Class).
1887–94	POWER, HUGH ALEXANDER	Mining (2nd Class).
1880–83	POWER, FRANCIS R. -	Mining (2nd Class), Metallurgy (2nd Class).
1884–88	PRADO, MAX - -	Mining (2nd Class).
1892–95	PRESCOTT, HARRY RICHMOND.	Metallurgy (2nd Class).
1891–94	PRETTY, WILLIAM HENRY	Mechanics (1st Class). Physics (2nd Class).
1899–02	PRICE, CHARLES WALTER-	Mechanics (1st Class).
1890–93	PRICE, SAMUEL WARREN -	Mining (1st Class). Metallurgy (2nd Class).
1889–92	PRIESTLEY, CHARLES W. -	Chemistry (1st Class).
1892–95	PRINGLE, ROBERT WILLIAM.	Mining (1st Class).
1894–97	PROBERT, FRANK HOLMAN	Metallurgy (2nd Class).
1895–99	PULLINGER, ERNEST HERBERT.	Mining (2nd Class).
1896–99	PULLINGER, ESSEX LLEWELLYN.	Mining (2nd Class).

Session.	Name.	Division.
1900–03	QUARTANO, ANDREW	Mining (2nd Class).
1898–01	QUARTANO, PETER	Metallurgy (1st Class)
1890–93	QUINN, GERALD G.	Chemistry (1st Class).
1900–03	RAWSON, WILLIAM	Mining (2nd Class).
1888–91	REES, ERNEST W.	Mechanics (1st Class).
1885–89	REYNOLDS, EDGAR J. R.	Chemistry (1st Class).
1894–97	REYNOLDS, WILLIAM COLEBROOK.	Chemistry (1st Class).
1896–99	RHIND, ALEXANDER	Mechanics (1st Class). Physics (1st Class).
1884–87	RICHARDS, JOHN J.	Metallurgy (1st Class).
1891–93	RICHARDSON, SAMUEL S.	Physics (1st Class).
1891–92	RICHARDSON, WILLIAM H.	Mining (1st Class).
1884–86	RICKARD, FORBES-	Metallurgy (2nd Class).
1887–90	RICKARD, JAMES A.	Mining (1st Class).
1882–85	RICKARD, T. ARTHUR	Metallurgy (1st Class).
1886–89	RIDDING, HOWARD C.	Metallurgy (1st Class).
1883–87	RIDEWOOD, WALTER G.	Biology (1st Class), Geology (1st Class).
1890–93	RIDGES, THOMAS J. C.	Biology (Zoology, 1st Class).
1890–93	RIDSDALE, EDWARD A.	Mining (2nd Class). Metallurgy (2nd Class).
1887–90	RILEY, HENRY C.	Mining (2nd Class).
1889–93	RIVINGTON, WALTER R. G.	Mining (2nd Class). Metallurgy (2nd Class).
1887–90	ROBERTS, MALCOLM	Mining (1st Class).
1889–92	ROBERTS, RICHARD	Mining (1st Class).
1896–99	ROBERTSON, WILLIAM	Chemistry (1st Class).
1899–03	ROBINSON, ARTHUR LIMNELL.	Mining (2nd Class).
1891–94	ROBINSON, CHARLES HAROLD.	Chemistry (2nd Class).
1897–02	ROBINSON, DANIEL	Physics (2nd Class).
1897–00	ROBINSON, DAVID WHITEOAK.	Metallurgy (2nd Class)
1897–02	ROBINSON, DENHAM RALPH	Mining (2nd Class).
1899–02	ROBINSON, LOUIS EDWARD	Zoology (1st Class).
1898–02	ROBINSON, REGINALD WILLIAM.	Mining (2nd Class).
1887–90	ROBSON, WILLIAM G.	Physics (1st Class).
1896–99	ROCHE, HAROLD FRASER	Mining (2nd Class).
1884–88	RODGER, JAMES W.	Chemistry (1st Class).
1887–90	ROGERS, GEORGE J.	Chemistry (1st Class).
1888–91	ROGERS, WILLIAM A. C.	Chemistry (1st Class).
1898–02	ROGERS, WILLIAM DAVID	Chemistry (2nd Class).
1900–03	ROLFE, FREDERICK PERCY	Mining (1st Class).

Session.	Name.	Division.
1898–01	RONCA, JAMES FRANCIS	Chemistry (2nd Class).
1897–00	ROOTHAM, HOWARD MELVILLE.	Mechanics (1st Class).
1883–86	ROSE, THOMAS K.	Metallurgy (1st Class).
1900–03	ROUILLARD, JEAN ANTHONY PHILIPPE.	Mining (2nd Class).
1893–97	ROUILLARD, RICHARD	Chemistry (2nd Class), Metallurgy (1st Class),
1898–01	ROUND, HENRY JOSEPH	Mechanics (1st Class).
1883–86	ROWDEN, WILLIAM C.	Metallurgy (1st Class).
1892–95	RUDD, WILLIAM HENRY	Metallurgy (1st Class).
1894–97	RUSSELL, GEORGE MARKS	Physics (1st Class). Mechanics (1st Class).
1896–99	RUTHERFORD, WILLIAM PATERSON.	Mining (2nd Class).
1890–93	RUTTER, ALFRED	Chemistry (1st Class).
1892–95	RYCE, GEORGE	Chemistry (2nd Class). Agriculture (2nd Class)
1888–91	SALTMARSH, JOHN G.	Chemistry (2nd Class).
1900–03	SAMPSON, ERNEST HENRY SOMERSET.	Mining (2nd Class).
1892–98	SANDERS, ALFRED DOUGLAS	Metallurgy (2nd Class). Mining (2nd Class).
1893–96	SANSOM, CHARLES ISAAC	Physics (2nd Class).
1898–01	SATTERLY, JOHN	Physics (1st Class).
1892–95	SAUNDERS, WILLIAM	Chemistry (2nd Class).
1900–03	SAWYER, RONALD ERNEST	Mining (2nd Class).
1886–89	SCHOFIELD, JAMES A.	Metallurgy (2nd Class).
1893–96	SCHOFIELD, JOHN	Physics (1st Class).
1896–99	SCHOLES, WILLIAM	Chemistry (1st Class).
1880–83	SCHRODER, GEORGE H.	Metallurgy (1st Class). Mining (2nd Class).
1890–94	SCHWARZ, ERNEST HUBERT LEWIS.	Geology (1st Class), and Honours in Palæontology.
1899–02	SCOBLE, WALTER ALFRED	Mechanics (1st Class).
1888–91	SCOTT, CHARLES C.	Mining (2nd Class).
1895–98	SCOTT, ERNEST ARTHUR	Biology (Zoology, 2nd Class).
1893–96	SCOTT, HENRY GEORGE	Mining (2nd Class).
1885–89	SCUDAMORE, WILLIAM	Agriculture (1st Class).
1900–03	SEEMAN, OTMAR ULRICH	Metallurgy (1st Class).
1899–02	SELVEY, WILLIAM MORRISH	Physics (1st Class).
1884–87	SEVERN, WALTER D.	Chemistry (2nd Class).
1888–91	SHACKLETON, WILLIAM	Physics (2nd Class).
1893–96	SHARROTT, THOMAS CHILWELL.	Chemistry (2nd Class)

Session.	Name.	Division.
1884–87	SHARWOOD, WILLIAM J. -	Mining (1st Class).
1896–99	SHAW, JOHN BEAUMONT	Mechanics (2nd Class).
1890–97	SHEPHERD, JOHN WILLIAM	Chemistry (2nd Class), Geology (1st Class).
1897–00	SHERLOCK, ROBERT LIONEL	Geology (1st Class).
1891–94	SIDEBOTHAM, CHARLES HOWARD.	Metallurgy (1st Class).
1884–87	SIMMONS, ARTHUR T. -	Physics (1st Class).
1894–98	SIMPSON, TOM - -	Mining (2nd Class).
1892–95	SIMPSON, WILLIAM EVAN -	Metallurgy (1st Class).
1884–86	SIORDET, HERBERT L. -	Mechanics (1st Class).
1893–97	SKEATS, ERNEST WILLINGTON.	Chemistry (1st Class), Geology (1st Class).
1889–91	SMEETH, WILLIAM F. -	Geology (1st Class), Metallurgy (1st Class).
1887–92	SMITH, CHARLES J. -	Mining (2nd Class).
1894–97	SMITH, CLARENCE -	Chemistry (1st Class).
1894–97	SMITH, ERNEST - -	Physics (1st Class)
1885–91	SMITH, ERNEST A. -	Metallurgy (1st Class).
1884–87	SMITH, ERNEST H. -	Chemistry (2nd Class).
1898–03	SMITH, FRANCIS WALLIS -	Mining (2nd Class).
1896–99	SMITH, FRANK EDWARD -	Physics (1st Class).
1887–90	SMITH, FREDERICK H. -	Geology (1st Class).
1891–94	SMITH, JAMES HENRY -	Mechanics (1st Class).
1896–99	SMITH, RAYMOND BERKELEY.	Mining (2nd Class).
1887–90	SMITH, SAMUEL W. J -	Physics (1st Class).
1896–99	SMITH, SIDNEY WILLIAM	Metallurgy (1st Class).
1888–91	SNELUS, GEORGE J. -	Metallurgy (2nd Class), Mining (1st Class).
1891–94	SNELUS, JOHN ERNEST -	Mining (1st Class).
1885–88	SOWERBUTTS, HENRY -	Chemistry (2nd Class).
1893–96	SOWTER, ROBERT - -	Physics (1st Class).
1886–89	SPEAK, SAVANNAH J. -	Metallurgy (1st Class)
1891–94	SPENCER, BERNARD ERIC -	Physics (1st Class).
1884–86	SPENCER, JOHN - -	Mechanics (1st Class).
1883–86	SPOONER, ARCHIBALD ST. G.	Metallurgy (1st Class).
1886–89	STANFIELD, RICHARD -	Metallurgy (1st Class).
1879–82	STANILAND, MEABURN -	Metallurgy (1st Class). Mining (2nd Class).
1894–97	STANLEY, GEORGE HARDY	Metallurgy (1st Class).
1888–93	STANSFIELD, ALFRED -	Metallurgy (1st Class with Honours).
1889–93	STANSFIELD, HERBERT -	Physics (1st Class).
1894–98	STANSFIELD, SAMUEL -	Physics (1st Class).
1887–90	STANTON, HENRY - -	Mining (1st Class).

Session.	Name.	Division.
1891–93	STARLING, SYDNEY GEORGE	Physics (1st Class).
1892–95	STENHOUSE, ERNEST -	Biology (Zoology, 1st Class).
1898–02	STENHOUSE, THOMAS	Chemistry (1st Class). Metallurgy (2nd Class).
1884–86	ST. STEPHENS, RAYNOR DE H.	Metallurgy (2nd Class).
1900–03	STEPHENS, WILLIAM HENRY.	Chemistry (2nd Class).
1880–84	STEPHENSON, ERSKINE H. B.	Metallurgy (2nd Class).
1898–01	STEPHENSON, JOE - -	Physics (1st Class).
1886–89	STEPHENSON, HERBERT F.	Chemistry (1st Class).
1899–02	STEVENS, MONTAGUE WHITE	Chemistry (2nd Class).
1890–93	STEVENSON, MARION W. -	Physics (2nd Class).
1897–00	STEWART, CHARLES HENRY	Metallurgy (1st Class). Mining (1st Class).
1897–01	STEWART, PHILIP CHARTERIS.	Mining (2nd Class). Metallurgy (2nd Class).
1895–98	STONIER, GEORGE ALFRED	Mining (1st Class).
1899–03	STOWELL, JOSEPH DOUGLAS	Mining (2nd Class).
1886–90	STREATFEILD, HUGH S. -	Mining (1st Class), Geology (1st Class).
1896–99	STRETTON, HALLYBURTON THOMAS.	Mining (2nd Class).
1887–90	STROMEYER, LOUIS -	Mining (2nd Class).
1896–99	STROMQUIST, SYDNEY GOODWIN.	Metallurgy (2nd Class).
1895–99	STUCKEY, LEONARD CECIL	Metallurgy (2nd Class). Mining (1st Class).
1887–90	STUDLEY, SAMUEL H. -	Metallurgy (1st Class).
1895–98	STUDT, FRANZ EDUARD -	Chemistry (2nd Class).
1889–93	STYLES, ROBERT C. -	Metallurgy (2nd Class).
1897–00	SUGDEN, SAMUEL - -	Chemistry (2nd Class).
1881–84	SUTTON ALFRED - -	Metallurgy (1st Class).
1899–02	SWIFT, HARRY JAMES	Chemistry (2nd Class).
1897–02	SWINNERTON, HENRY HURD	Zoology (1st Class).
1892–95	SWORDS, WILLIAM FRANCIS	Chemistry (1st Class).
1891–94	TALBOT, FREDERICK RICHARD SAMUEL.	Physics (2nd Class).
1900–03	TANNOCK, WILLIAM -	Physics (1st Class).
1889–94	TARVER, PERCY - -	Chemistry (2nd Class).
1886–89	TATE, WILLIAM - -	Chemistry (1st Class with Honours).
—89	TAYLOR, ALBERT - -	Chemistry (1st Class), Metallurgy (1st Class).
—01	TAYLOR, GEORGE STEVENSON,	Mechanics (1st Class).

Session.	Name.	Division.
1893–96	TAYLOR, WILLIAM ARTHUR	Mechanics (1st Class).
1894–97	TEMPLEMAN, JAMES PELHAM GERARD.	Chemistry (2nd Class).
1885–88	THOMAE, WILLIAM F.	Mining (1st Class).
1892–95	THOMAS, JOHN	Chemistry (1st Class).
1896–99	THOMAS, WILFRED	Biology, (Botany, 2nd Class).
1885–88	THOMPSON, CHARLES G.	Mining (1st Class).
1884–86	THOMPSON, COURTENAY W.	Mining (2nd Class).
1889–92	THOMPSON, EDWARD C.	Chemistry (1st Class).
1889–92	THOMPSON, FRANK E.	Chemistry (2nd Class)
1889–91	THOMPSON, GEORGE R.	Mining (1st Class).
1891–94	THOMPSON, JAMES	Metallurgy (1st Class)
1891–94	THORBURN, FREDERICK HARRISON.	Metallurgy (2nd Class).
1899–02	THORNTON, THOMAS	Botany (2nd Class)
1888–91	TINDALL, WILLIAM F. P.	Metallurgy (1st Class).
1894–97	TOD, HERBERT NCELE	Mining (2nd Class).
1895–98	TOD, STUART	Mining (2nd Class).
1898–00 1901–03	TOM, ISIDORE	Mining (2nd Class).
1895–98	TOMKINS, JOHN ARTHUR	Physics (2nd Class).
1896–99	TOPHAM, HANSON	Mechanics (1st Class).
1890–93	TOWNSEND, HARRY POYSER	Mining (2nd Class).
1882–86	TREVOR, TUDOR G.	Metallurgy (1st Class).
1886–89	TRUSCOTT, SAMUEL J.	Mining (1st Class).
1892–95	TUBBS, WILLIAM EDWARD	Mechanics (2nd Class).
1898–01	TUCKER, WILLIAM SANSOME	Physics (2nd Class).
1892–96	TURNER, BASIL WILLIAM	Metallurgy (1st Class). Mining (1st Class).
1878–83	TURNER, THOMAS	Metallurgy (1st Class).
1890–95	TURNER, WILLIAM JAMES	Mining (2nd Class), Metallurgy (2nd Class).
1884–86	TUTTON, ALFRED E.	Chemistry (1st Class).
1897–00	TWITE, HAROLD LLEWELLYN.	Mining (2nd Class).
1896–99	TYLEY, FREDERICK JOHN	Mechanics (1st Class).
1889–92	VARTY, THOMAS N.	Mining (1st Class).
1894–98	VAUGHAN, JAMES EVELYN	Metallurgy (2nd Class), Mining (2nd Class).
1895–98	VERITY, EDMUND R.	Mechanics (1st Class), Physics (1st Class).
1891–94	VERNEY, HARRY	Mechanics (1st Class).
1896–00	VINCENT, JESSE	Metallurgy (2nd Class).
1892–95	VINCENT, JOSEPH HERBERT	Physics (2nd Class).
1887–90 and 1894–95	VREDENBURG, ERNEST WATSON.	Mining (2nd Class). Geology (1st Class).

Session.	Name.	Division.
1897–00	WADE, FRANK - -	Chemistry (2nd Class).
1886–89	WADSWORTH, GEORGE H. -	Chemistry (1st Class).
1900–03	WAGER, HORACE ATHELSTAN.	Biology (Botany, 1st Class).
1893–98	WALFORD, FREDERICK -	Mechanics (2nd Class).
1892–94	WALKER, GEORGE WALKER.	Physics (1st Class).
1898–01	WALKER, GEORGE -	Metallurgy (2nd Class).
1898–01	WALKER, HAROLD -	Geology (1st Class).
1898–01	WALLACE, WILLIAM McGREGOR.	Mechanics (1st Class), Physics (1st Class).
1897–00	WALL, GEORGE - -	Mechanics (1st Class), Physics (1st Class).
1893–95 1901–03	WALLER, HENRY TRENCH	Metallurgy (1st Class).
1894–98	WALLIS, AGNES ANNIE -	Biology (Botany, 1st Class).
1882–85	WALLS, ISAAC T. - -	Chemistry (2nd Class).
1897–00	WALTON, DENYS - -	Mechanics (1st Class).
1879–82	WALTON, JOSEPH P. -	Metallurgy (1st Class).
1888–93	WAN, PING YAN - -	Metallurgy (2nd Class). Mining (1st Class).
1893–98	WARD, OSMER BERNARD -	Mining (1st Class), Metallurgy (1st Class)
1888–91	WARE, MORTON - -	Chemistry (1st Class).
1893–97	WATERMEYER, GOTTFRIED ANDREAS.	Mining (2nd Class), Metallurgy (2nd Class).
1886–89	WATKINS, ARTHUR O. -	Mining (2nd Class).
1892–95	WATSON, JOHN - -	Chemistry (2nd Class).
1891–94	WATSON, WALTER HENRY	Chemistry (1st Class).
1884–86	WATSON, WILLIAM S. -	Mechanics (1st Class).
1887–90	WATSON, WILLIAM -	Physics (1st Class) with Honours.
1900–03	WATT, FRANCIS LANGSTON	Chemistry (1st Class).
1890–93	WAUGH, PERCIVAL BENTLEY.	Mining (1st Class), Metallurgy (2nd Class).
1900–03	WEBB, LEONARD ALEC VERNON.	Mechanics (1st Class).
1895–98	WEBBER, REGINALD BENONI.	Mining (2nd Class).
1899–02	WENT, PHILIP BRANDFORD ARCHIBALD	Mining (2nd Class).
1893–97	WENTWORTH, D'ARCY -	Metallurgy (2nd Class), Mining (2nd Class).
1894–97	WEST, CHARLES ALFRED -	Chemistry (2nd Class).
1891–94	WEST, GEORGE STEPHEN -	Biology (Zoology, 1st Class).
1889–92	WEST, HOWARD - -	Mining (2nd Class).

Session.	Name.	Division.
1889–92	WEST, WILLIAM - -	Biology (Botany, 1st Class).
1889–92	WESTERN, FRANK -	Metallurgy (2nd Class).
1887–94	WETHERELL, ERNEST WILLIAM.	Geology (1st Class).
1889–92	WHALLEY, SYDNEY - -	Chemistry (2nd Class)
1892–96	WHALLEY, WILLIE - -	Physics (2nd Class).
1885–88	WHITAKER, JAMES - -	Mechanics (1st Class).
1896–99	WHITE, ARTHUR LEE -	Chemistry (1st Class).
1879–82	WHITE, JOHN H. - -	Metallurgy (1st Class).
1894–97	WHITE, WILLIAM HERBERT	Physics (1st Class).
1896–99	WHITEHEAD, JAMES -	Chemistry (2nd Class).
1898–03	WHITELEY, MARTHA ANNIE	Chemistry (1st Class).
1886–90	WILKINSON, DAVID - -	Physics (1st Class). Metallurgy (1st Class).
1890–93	WILKINSON, HENRY - -	Agriculture (1st Class).
1897–00	WILLEY, GEORGE BRYDON	Metallurgy (2nd Class).
1898–01	WILLIAMS, CORNELIUS -	Mechanics (1st Class).
1895–98	WILLIAMS, HAROLD BETHUNE.	Mining (2nd Class).
1884–86	WILSON, ALEXANDER G. -	Mining (1st Class).
1894–97	WILSON, GEORGE - -	Physics (1st Class), Mechanics (2nd Class).
1889–94	WILSON, ROBERT ALEXANDER.	Mining (2nd Class).
1898–03	WILTENOOM, CHARLES HORNE	Mining (2nd Class).
1882–85	WOAKES, ERNEST - -	Mining (1st Class).
1889–92	WOLFENDEN, JOHN H. -	Chemistry (1st Class).
1886–89	WOOD, JOHN E. - -	Mining (1st Class).
1887–91	WOOD, SIDNEY - -	Chemistry (1st Class). Physics (1st Class).
1889–92	WOODALL, HERBERT J. -	Physics (2nd Class).
1887–90	WOODHOUSE, CLAUDE H. C.	Biology (Botany, 1st Class).
1882–85	WOODWARD, MARTIN F. -	Biology (1st Class).
1899–02	WRAIGHT, ERNEST ALFRED	Metallurgy (1st Class).
1891–95	WRATTEN, FREDERICK PERCY.	Chemistry (2nd Class).
1896–99	WRIGHT, HERBERT -	Biology (Botany, 1st Class).
1897–02	WRIGHT, RICHARD LLOYD	Metallurgy (1st Class). Mining (2nd Class).
1882–85	WYATT, GEORGE H. - -	Physics (2nd Class).
1886–90	WYATT, THOMAS M. -	Chemistry (2nd Class).
1881–84	WYNNE, WILLIAM PALMER	Chemistry (1st Class).
1888–91	YATES, JOHN - - -	Mining (1st Class).
1888–91	YOUNG, BENJAMIN - -	Metallurgy (2nd Class).
1885–88	YOUNG, JAMES - - -	Chemistry (1st Class).

Teaching Associates of the Royal College of Science.

Session.	Name.	Division.
1891–94	YOUNG, WILLIAM DAWSON	Mechanics (1st Class).
1900–03	YUN, KUI IK - - -	Mining (2nd Class).
1901–02	GOUGH, GEORGE CECIL -	Geology.
1901–02	GRIFFITH, O. W. - -	Physics.
1902–03	GWINNELL, RUSSELL FROST	Geology.
1901–02	JAMES, WILLIAM HENRY NICHOLS	Physics.
1901–02	ROBERTSON, WILLIAM -	Chemistry.
1901–02	SMITH, FRANK EDWARD -	Physics.

EXAMINATION PAPERS.
1903.

Mathematics.

Class A.

FEBRUARY 2ND, 1903. 2 P.M. TO 5 P.M.

[A set of Mathematical Tables is supplied to each Candidate.]

Attempt EIGHT *questions only, four in each Section.*

SECTION I.

1. Given $\sqrt{2} = 1{\cdot}4142$ and $\sqrt{3} = 1{\cdot}7321$, find the value of $\frac{1}{\sqrt{6} - \sqrt{2}}$ correct to three places of decimals, using a contracted method of multiplication.

   Compute $3^{-5{\cdot}246}$ and $\cdot 042^{20{\cdot}476}$, with the aid of the tables supplied, giving the answers to four significant figures. (14)

2. Given $L = (D + d)\left\{\frac{\pi}{2} + \theta + \frac{1}{\tan\theta}\right\}$, and $\sin\theta = \frac{D + d}{2c}$; find the value of L when $c = 20$, $D = 6$, and $d = 3$. (12)

3. The perimeter of a right-angled triangle is six times as long as the shortest side. What is the ratio of the two sides containing the right angle? (12)

4. Resolve into factors:—

   (i) $12x^2 - 25xy + 12y^2$.
   (ii) $a^8 + a^4b^4 + b^8$.
   (iii) $x^4 + x^2y^2 + y^4 - 2xy - 1$.

   Show that a is a factor of the expression

   $$(a + b)^5 (a^3 + c^3) - (a + c)^5 (a^3 + b^3).$$

5. Solve any two of the equations (a), (b), and (c).

   (a) $x^2y + xy^2 = 0{\cdot}15$ }
   $x^3 + y^3 = 0{\cdot}152$ }

   (b) $x^2 + 4x + y^2 - 4y + 10 = 2$.

   (c) $2^x \times 7^y$

6. Answer only one part of this question, (*a*) or (*b*).

(*a*) By the use of squared paper, show that the equation $x^3 - 2 \cdot 4x^2 - 3x + 7 \cdot 2 = 0$ has three real roots. Find, to two places of decimals, the least positive value of x which satisfies this equation.

(*b*) Find a value of x which satisfies the equation

$$x^2 - 5 \log_{10} x - 2 \cdot 531 = 0.$$ (12)

7. Between one census and the next, the native population of a town increased by 8 per cent., while the number of foreigners decreased from 200 to 150. The increase in the total population was 7 per cent.; what was the total population at the second census? (12)

8. In some experiments in towing a canal boat the following observations were made; P being the pull in pounds and v the speed of the boat in miles per hour.

v	1·68	2·43	3·18	3·60	4·03
P	76	160	240	320	370

Plot log v and log P upon squared paper, and give an approximate formula connecting P and v. (12)

Section II.

9. Write in a table the values of the sine, cosine, and tangent of the following angles:—

25°, 155°, 205°, 335°, 385°.

Find the length of an arc on the sea which subtends an angle of one minute at the centre of the Earth, supposing the Earth a sphere of diameter 7,920 miles.

Give the answer in miles to three places of decimals. (12)

10. Prove the formula:—

$$\sin (A + B) = \sin A \cos B + \cos A \sin B.$$

Verify this formula for the case $A = 45°$, $B = 30°$, using the table of sines and cosines given in the Examination Tables supplied you. (12)

11. The sides of a triangle are 1·3, 1·4, and 1·5 feet respectively: find the angles.

Show that the area of this triangle is 0·84 square feet.

What is the area of a triangle whose sides are 13, 14, and 15 feet respectively? (12)

12. A passenger on a steamer moving due North along a straight reach of a lake, at a uniform speed of 10 miles an hour, observed at a certain instant that the bearing of a tower on shore made an angle of 28° with the direction of the steamer, and 3 minutes ater an angle of 54°. Find the distance of the tower from the track of the steamer.

Find also the time from the second observation before the tower will be abreast the steamer. (12)

13. From the top of a vertical cliff 100 feet high, forming one bank of a river, the angles of depression of the top and bottom of a vertical cliff which forms the opposite bank of the river are 29° and 65° respectively. Find the height of the cliff on the opposite bank and the width of the river. (12)

14. Suppose s the distance in feet passed through by a body in the time t seconds is $s = 12t^2$. Find s when $t = 2{\cdot}5$, when $t = 2{\cdot}51$, and also when $t = 2{\cdot}501$. What is the average speed in each of the two short intervals of time after $t = 2{\cdot}5$? When the interval of time is made shorter and shorter, what does the average speed approximate to? (12)

15. Find from first principles the differential coefficient with respect to x of each of the following functions of x:—

$$x^2, \quad \sqrt{x}, \quad \frac{1}{\sqrt{x}}, \quad \sin x.$$

Write down the differential coefficient with respect to x of each of the following functions of x:—

ax^n, $(a + bx^n)^m$, $\sin(a + bx)$, $\cos(a + bx)$, e^{a+bx}

Mechanics.

PART 1.

FEBRUARY 13TH, 1903. 10 A.M. TO 1 P.M.

Only SIX *questions to be answered.*

1. Distinguish between *force*, *work*, and *horse-power*. Find the pull on the draw-bar of a locomotive which develops 600 actual horse-power when travelling at 60 miles an hour—the power spent in propelling the locomotive being 40 per cent. of the whole. (16)

2. Find the resultant of the given system of uniplanar forces. That is find a, A, and $\boldsymbol{a}$ in the vector equation.

$$\underset{a}{A}\ \underset{a}{=}\ \underset{1\cdot2\ \ 160^\circ}{2\cdot1\ \text{tons}} + \underset{1\cdot7\ \ 120^\circ}{1\cdot8\ \text{tons}} + \underset{2\cdot3\ \ 80^\circ}{3\cdot2\ \text{tons}} + \underset{3\cdot7\ \ 0^\circ}{1\cdot6\ \text{tons}}$$

(16)

3. A braced cantilever supporting a roof and subject to given loads is shown in the diagram (Fig. 1).

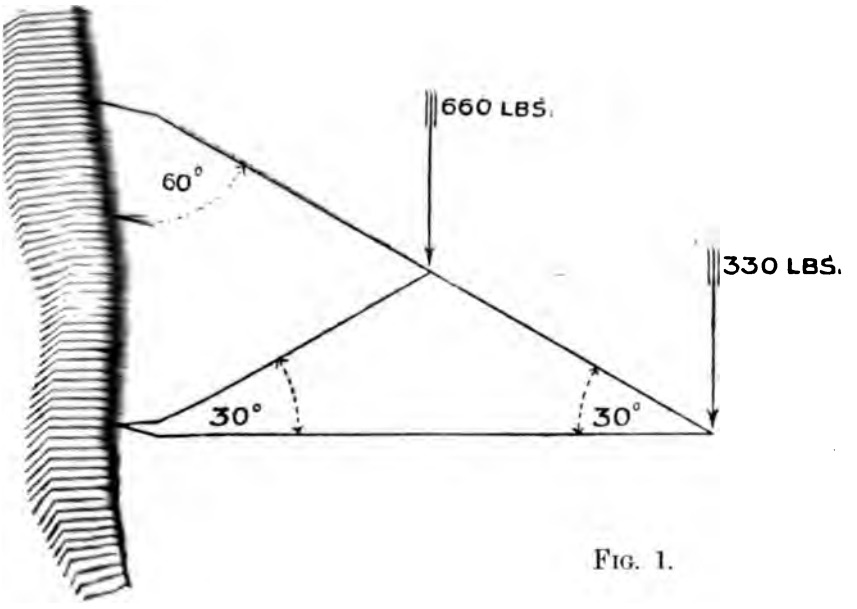


FIG. 1.

Determine the forces in the four bars of the frame, distinguishing pulls from thrusts. (16)

4. In a crane the chain-barrel is driven by a 25 horse-power motor on the spindle of which is keyed a spur-wheel of 14 teeth. This gears with a spur-wheel of 68 teeth keyed to the same spindle as a spur-wheel of 12 teeth. The last wheel gears with a spur-wheel of 50 teeth keyed to the same spindle as a wheel of 25 teeth, and the latter gears with a wheel of 54 teeth keyed to the chain barrel spindle which is $16\frac{1}{2}$ inches in diameter. It is found that when the motor spindle makes 200 revolutions per minute, 25 horse-power are required to lift a load of 10 tons. Find the efficiency of the crane. (16)

5. The four weights W_1, W_2, W_3, W_4 (Fig. 2), rotate in one plane about an axis—their magnitudes and the radii at which they act being given in the table.

Weight.	Radius in feet.	Magnitude in lbs.
W_1	·5	10
W_2	1·0	8
W_3	1·25	6
W_4	·75	12

Find graphically the equivalent single mass, in magnitude and direction, acting at a radius of 1 foot; and estimate the total displacing force on the shaft when the revolutions are 200 per minute. (16)

6. A radial valve gear actuates a slide valve. The outside lap is $\frac{7}{8}$", and the inside lap $\frac{3}{8}$". By shifting the gear we obtain the following :—

Half travel	2·50"	2·02"	1·58"	1·25"
Advance	26·5°	33·5°	45°	63·5°

Select any *one* of these cases, and find the position of the crank at *admission*, *cut-off*, *release*, and *compression*. Draw a possible indicator diagram for this case. Neglect the obliquity of the connecting rod. (12)

7. Experiments on the loss of head in a lead pipe of ·4 inches diameter give, for a length of $3\frac{1}{2}$ feet the following results :—

Velocity of flow in feet per second = v.	8·04	11·67	14·43	17·41	19·90
Observed difference of head in feet of water = h_1.	3·03	6·11	9·07	12·21	15·62

Test whether the results can be expressed by a formula of the type $h_1 \propto v^n$, and if so, obtain the value of n. Moreover, if we assume that

$$h_1 = f \cdot \frac{4l}{d} \cdot \frac{v^2}{2g},$$

in which the length l and diameter d of the pipe are in feet, estimate the value of the coefficient f. (16)

8. A pulley 3 feet in diameter, running at 150 revolutions a minute has to transmit 6 horse-power by means of a single belt. The pull on the tight side is $2\frac{1}{2}$ times that on the slack side, and the greatest pull allowed is 66 lbs. per inch of width of the belt. Find the breadth of belt required. (16)

9. A car weighs 10 tons ; what is its mass in engineers' units ? It is drawn by the pull P lbs., varying in the following way, t being seconds from the time of starting.

P	1020	980	882	720	702	650	713	722	805
t	0	2	5	8	10	13	16	19	22

The retarding force of friction is constant and equal to 410 lbs. Plot $P - 410$ and the time t, and find the *time average* of this excess force. What does this represent when it is multiplied by 22 seconds? What is the speed of the car at the time 22 seconds from rest? (16)

10. Explain what is meant by the dryness fraction of steam?

In order to determine the dryness fraction of steam, the steam is run into an iron tank containing water, and there condensed. In one experiment the tank initially contained 4,884 lbs. of water at a temperature of 12° C., the tank itself weighing 876 lbs. Steam at a temperature of 178° C. was run into the tank from the boiler, and the final temperature after 110·2 lbs. of steam had been run in was 26° C. Assuming the water and the tank to be of uniform temperature, and the specific heat of iron $\frac{1}{8}$th, find the dryness fraction of boiler steam. (16)

11. A turbine is supplied with water having an available fall of 50 feet. The flow is gauged by a rectangular notch, the height over the sill being 9 inches and the width 15 inches. The turbine developes 9¼ horse-power. Find its efficiency.

N.B.—If Q cubic feet of water flow per second over a rectangular notch, of width L feet and height H feet over the sill

$$Q = 3 \cdot 33 \left(L - \tfrac{1}{5} H\right) H^{\frac{3}{2}}.$$

How is this formula obtained? (18)

12. A spiral spring is supported at the upper end, and when a weight of 7 lbs. is hung on to the lower end, a deflection of 0·1 foot is produced.

Find the time of a vertical oscillation: (1), neglecting the mass of the spring; (2), supposing the spring weighs 0·6 lb. and a proper allowance for its mass is added to the 7 lb. weight.

Prove the formulæ you use. (18)

Mechanics.

PART I.

FEBRUARY 13TH, 1903. 2 P.M. TO 5 P.M.

[*Only* SIX *questions* [illegible] *to be answered.*]

1. A mass of 20 lbs. moving with a velocity of 9[illegible] per second impinges on a [illegible] velocity of 12[illegible] feet per [illegible] mon velocity is [illegible]

Find also the change of momentum which has occurr in the first mass. If the duration of the blow be second, what is the average force which acts on this ma during impact? (

2. A beam, 40 feet span, supported at both ends, loaded over a length of 15 feet from the left-ha support with an uniform load of 2 tons per foot-r Draw, to scale, the curves of shearing force and bendi moment, and find, independently, the maximum value the bending moment. (

3. In a lifting machine an effort of 26·6 lbs. just rais a load of 2,260 lbs.; what is the mechanical advantag If the efficiency is 0·755, what is the velocity ratio? On this same machine an effort of 11·8 lbs. raises a lo of 580 lbs., what is now the efficiency? (

4. In a 10-ton crane the jib is 35 feet long, the 30 feet long, and the crane post 15 feet high. The cha crosses the crane post at its middle point, and the tensi in it is, by means of tackle, half the load carried. Fi the forces in the tie and jib when carrying the f load. (

5. A Cornish boiler is 6 feet diameter and the worki pressure is 80 lbs. per square inch. The strength of t longitudinal joints is 70 per cent. of the unhurt plate. the working stress be taken as 10,000 lbs. per square inc find the thickness of the shell. (

6. An engine uses, per indicated horse-power-ho 18 lbs. of dry steam of 180 lbs. per square inch gau pressure (corresponding temperature 193° C.), the fe water being at 30° C. Neglecting radiation from t engine, find how much heat goes into the surface co denser per horse-power-hour. If the water leaves t condenser at 60° C., how much of this heat is carried by the circulating water? (

7. The slide valve of a horizontal steam engine deriv its motion from a point P in a link A_1A_2, where

$$A_1P = \tfrac{1}{3}A_1A_2.$$

The horizontal displacements of A_1 and A_2 for a crank position θ are given by the equations

$$x_1 = 2{\cdot}5'' \sin(\theta + 27°);$$
$$x_2 = 2{\cdot}6'' \sin(\theta + 150°).$$

The resulting motion of the valve being defined by t equation

$$x = a'' \sin(\theta + \alpha),$$

find the half travel a'' and the advance $\alpha°$. (

8. It is found that a ram, 10 inches diameter, can lift a load of 20 tons with an uniform speed of 6 inches per second when supplied with water from an accumulator working at a pressure of 750 lbs. per square inch. If the frictional losses vary as the square of the speed, find the limiting uniform velocity of the ram when running quite light. (16)

9. The successive positions of a piston at intervals of time of $\frac{1}{16}$th of a second are 0·0, 0·024, 0·097, 0·206, 0·341 feet respectively.

Determine the velocity and acceleration of the piston at successive intervals. Draw a diagram showing the velocity and acceleration at any time. Read off the acceleration when $t = 0{\cdot}05$ second. (16)

10. In an electric railway the average distance between stations is half a mile, the running time from start to stop is $1\frac{1}{2}$ minutes, and the constant speed at which the trains run between the end of acceleration and beginning of retardation is 25 miles an hour. The weight of each train is 120 tons and the frictional resistance is 11·2 lbs. per ton. Assuming that the acceleration and retardation are uniform and numerically equal, estimate the necessary tractive force at starting on the level. (16)

11. Steam is cut off at $\frac{1}{3}$ stroke, and expands by the law pv constant; find the average pressure in the forward stroke as a fraction of p_1 the initial pressure. The back pressure is 18 lbs. per square inch, together with 10 lbs. per square inch representing the friction of the engine. The piston is 15 inches diameter, crank 1 foot, two strokes per revolution, 120 revolutions per minute; find the actual horse-power for each of the three values of p_1 given in the table below. One pound of steam of pressure p_1 has the volume u_1 cubic feet given in the table; what weight of steam W is indicated per hour in each case?

Show, on squared paper, the probable relationship of W and the horse-power in this engine, when p_1 varies but the cut-off of $\frac{1}{3}$ is not altered.

p_1	150	120	80
u_1	2·00	2·51	

12. A test bar, ·74 inch diameter and 8 inches long between gauge points, gave when tested for torsion the following results :—

Twisting moment in inch-lbs.	20	40	60	80	100	120	140	160	180	200
Twist in degrees -	·038	·075	·114	·151	·189	·228	·269	·310	·350	·514

Estimate the maximum shearing stress at the elastic limit and the value of the modulus of rigidity. (18)

Elementary Mechanics

(For Students entering Physics, Part I.).

11TH FEBRUARY, 1903. 10 A.M. to 1 P.M.

N.B.—Take $g = 32{\cdot}2$ in foot-second units $= 981$ in C.G.S. units.

1. What is meant by the "resultant of two forces"? State the propositions known as the "parallelogram of forces" and the "polygon of forces."

   Four forces of 3, 5, 8 and 17 lbs. act at a point and have directions parallel to the sides of a square taken in order, find the magnitude of their resultant.

2. Define the "moment" of a force about a point, and prove that the moments of two forces about a point on the line of action of their resultant are equal and opposite. Apply the above result to find the relation between the effort and the load in the arrangement known as the "wheel and axle."

3. A body apparently weighs 15 grammes in one of the pans of a false balance, and 17 grammes when placed in the other pan. Find to the nearest centigramme the true weight of the body.

4. Define the "centre of gravity" of a body, and explain how the common centre of gravity of two bodies of known weight can be found when the centre of gravity of each body is already known.

   A square frame is made up of four pieces of wire, each of which is uniform and 12 centimetres in [illegible] but one of the sides is twice as heavy as others; find the position of the centre the frame.

5. A pair of pincers has handles 8 inches long and jaws 1·25 inches long measured from the centre of the rivet. What pressure can you produce between the jaws if the strength of your squeeze is 60 lbs. and you apply it at 1·5 inches from the end of the handle?

6. A boat is being rowed in a North-Easterly direction at the rate of 4 miles an hour relatively to the water: the current, which is running South, carries the boat so that its actual course is due East; find the resultant speed of the boat, and the speed of the current.

7. Two trains, of length 100 ft. and 150 ft. respectively, are moving on parallel lines in opposite directions, one at 40 miles an hour, the other at 60 miles an hour; find how long they take to pass one another.

8. Define "acceleration" and establish the formula $S=ut+\frac{1}{2}ft^2$, for the space described in time t under uniform acceleration f.

   A particle starts from rest at a given point with an acceleration of 7 ft.-sec. units, and 2 seconds later another particle leaves the same point in the same direction with a velocity of 9 ft. per sec. and an acceleration of 9 ft.-sec. units: find how many seconds elapse before the second particle overtakes the first.

9. Two weights W and w are connected by a light string passing over a smooth pulley whose inertia is to be neglected; find the acceleration of the weights and the tension of the string.

   If $W=400$ grammes, and $w=300$ grammes, and if after moving from rest for 2 seconds, 100 grammes is detached from W, find the subsequent velocity of the now equal weights.

10. Give the definitions of a "dyne" and an "erg" in the C.G.S. system. A weight is hung from a string 50 centimetres long. The weight is displaced laterally till it is at the same horizontal level as the point of suspension and is then released. Find its velocity as it passes through the lowest point of its path.

Theory of Laboratory Practice and Chemical Arithmetic.

PART I.

FEBRUARY 4TH, 1903. 10·15 A.M. TO 1·15 P.M.

EIGHT questions only are to be attempted.

1. Write equations expressing the action of diluted nitric acid on the following substances: (*a*) copper, (*b*) chalk, (*c*) borax, (*d*) red lead.
2. Express by symbols the ions of the following compounds: caustic potash, ferrous chloride, ferric chloride, zinc sulphate, potassium permanganate, stannous chloride, alum, sodium thiosulphate.
3. What is the effect on litmus of each of the following salts dissolved in water, and how is the effect explained:—NaH_2PO_4, Na_2HPO_4, borax, ferric chloride?
4. What volume of oxygen at 15° C. and 740mm. is required for the complete combustion of 10 grams of carbon bisulphide and of 100 cc. of marsh gas?

   C = 12, S = 32.
5. What is the action of hydrogen sulphide on aqueous solutions of (1) zinc sulphate, (2) ferric chloride, (3) copper sulphate, (4) sodium arsenite, (5) sulphurous acid?
6. Explain the chief uses of (1) ammonium chloride, (2) sodium phosphate, (3) platinic chloride, (4) ammonium sulphide, in qualitative analysis.
7. Explain how chlorides and nitrates are detected in the presence of iodides, and carbonates in the presence of sulphites.
8. What is the action of heat on (1) potassium nitrate, (2) borax, (3) potassium cyanide, (4) microcosmic salt, (5) sodium carbonate?

   Give examples of the use of these compounds in the dry way.
9. What impurities would you expect to find in (*a*) commercial caustic soda, (*b*) commercial sulphuric acid (oil of vitriol), (*c*) commercial hydrochloric acid? How would you test for these impurities?

10. Explain how you would prepare a decinormal solution of sulphuric acid.

    50 c.c. of a solution of potassium nitrate, after reduction with aluminium and soda, are distilled, and the ammonia collected in 100 c.c. of decinormal sulphuric acid. The resulting solution requires 20 c.c. of decinormal soda for neutralisation. How much potassium nitrate was dissolved in a litre of the given solution?

11. If you were supplied with a mixture of potassium carbonate and potassium nitrite, and instructed to ascertain the composition of the gas evolved from it on treatment with dilute sulphuric acid, describe carefully how you would proceed.

12. What weight of commercial manganese peroxide containing 80 per cent. of MnO_2 would be required to yield chlorine sufficient to decompose exactly 20 grams of potassium iodide?

    Mn = 55, I = 127, K = 39.

General Theoretical Chemistry.

PART I.

FEBRUARY 9TH, 1903. 10.15 A.M. TO 1.15 P.M.

To be answered by all.

1. Write not more than two pages on any substance or subject, included in the course, to which you have given special attention.

From the following questions SEVEN *may be selected, provided the subject of your first answer is not repeated. Equations must be written whenever necessary for explanation.*

2. Describe briefly the chief discoveries in chemistry made at the end of the eighteenth and beginning of the nineteenth century, and their influence on theory.

3. Describe the properties and chief reactions of the compounds represented by the formulæ (*a*) NO, (*b*) H_3NO, (*c*) HNO_3.

4. Tabulate the characters of *one* of the following groups of elements, and indicate their position in the periodic scheme; (*a*) Ba, Sr, Ca; (*b*) Mg, Zn, Cd; (*c*) P, As, Sb.

5. Write constitutional formulæ for sulphuric and acetic acids, and explain in each case the evidence on which the formula is based.

6. Describe the colour of each of the following compounds in the solid state and in dilute solution in water.

Anhydrous cupric sulphate, cupric bromide, cobalt chloride, cobalt iodide, ferric chloride, lead iodide. How are these and other similar phenomena explained?

7. Give an account of the production of cast iron from clay iron stone.

8. Give an outline of the history of ozone, and indicate the chief facts by the aid of which the formula O_3 was established.

9. The atomic weight of carbon is 12. Explain the reasons which have led to the adoption of this value.

10. State and explain the law regulating the solubility of gases in water. What happens when aqueous solutions of (*a*) carbon dioxide, and (*b*) hydrogen chloride are boiled?

11. What is the chief source of phosphorus, and how is the element obtained from it? Describe the preparation and properties of the compounds it forms with chlorine and give the reasons for assigning the formula PCl_5 to one of them.

12. How would you prepare a specimen of pure carbon monoxide? Describe carefully the experiments you would make in order to prove the molecular composition of the gas.

Practical Chemistry.

PART I.

FEBRUARY 5TH, 1903. 10 A.M. TO 5 P.M.

A.

Analyse the mixture qualitatively.

B.

You are supplied with two substances of which a portion is to be heated gradually to redness in a dry test tube.

You are required to observe and record carefully all that happens in each case.

You are not expected to analyse these substances, and no credit will be given for anything beyond a statement of your observations on exposing them to heat.

The results must be written out in ink and finished by 5 o'clock.

Practical Chemistry.

PART I.

FEBRUARY 6TH, 1903. 10 A.M. TO 5 P.M.

Solutions are provided containing copper sulphate and ferrous sulphate respectively. Determine the amount of copper by a gravimetric and the amount of iron by a volumetric process.

Give a brief account of the process employed in each case and report your results in grams [illegible] copper and iron respectively in a litre [illegible] solution.

Biology.

Botany (Elementary Course).

1ST PAPER.

FEBRUARY 13TH, 1903. 10 A.M. TO 1 P.M.

[Not more than *six* questions are to be attempted.]

1. Write a short account of the various modes in which plants obviate an excessive loss of water. Illustrate your answer by reference to definite examples.

2. Give some account of the establishment of a root in the soil, with especial reference to its mechanical fixation.

3. In what way would you investigate the relation of oxygen to the manifestation of irritability in a plant?

4. Explain the principle of the Klinostat. State how it may be employed to investigate the relative positions *naturally* taken up by the different organs of the same plant.

5. What is meant by proterandry? Describe as fully as you can the proterandrous arrangements in any two flowers you may select, and indicate the significance of such arrangements.

6. Point out the chief modifications in anatomical structure met with in aquatic flowering plants known to you, and contrast them with the normal structure of aerial plants.

7. Cite examples of the production of mucilage in plants, and explain the importance of mucilage in their economy.

8. What is meant by symbiosis? Explain by reference to the structure of a lichen, and state how the nature of this structure has been ascertained.

2ND PAPER.

FEBRUARY 13TH, 1903. 2 P.M. TO 5 P.M.

1. Examine transverse sections of the stem of the specimen A. Investigate as fully as possible the develop- [illegible] and sketch a complete series

[illegible]e preparations B. and C.

3. Examine the flowers D and E, and describe the arrangements for pollination. Explain in what respects D differs from usual types of flowers.

4. Indicate, by means of flag-labels, the special features of morphological importance exhibited in specimen F.

5. Interpret and comment upon the growth-curve G. [The abscissæ represent three-hourly intervals of time; the ordinates, the increments of growth in millimetres; the dotted line indicates the temperature variation.]

(*See* opposite page.)

3RD PAPER.

FEBRUARY 14TH, 1903. 10 A.M. TO 1 P.M.

[Not more than *six* questions are to be attempted.]

1. Describe and contrast the vascular strand of a Fern stem with the bundle of an Angiosperm. Explain the relation of the strand or bundle in each case to the vascular system as a whole.

2. Write a short account of the structure of a sieve-tube. Describe the changes that occur in its living contents, and indicate its probable function.

3. Describe the origin of the corky mantle in any stem. What structural features in the cork influence the general character of the bark as a whole.

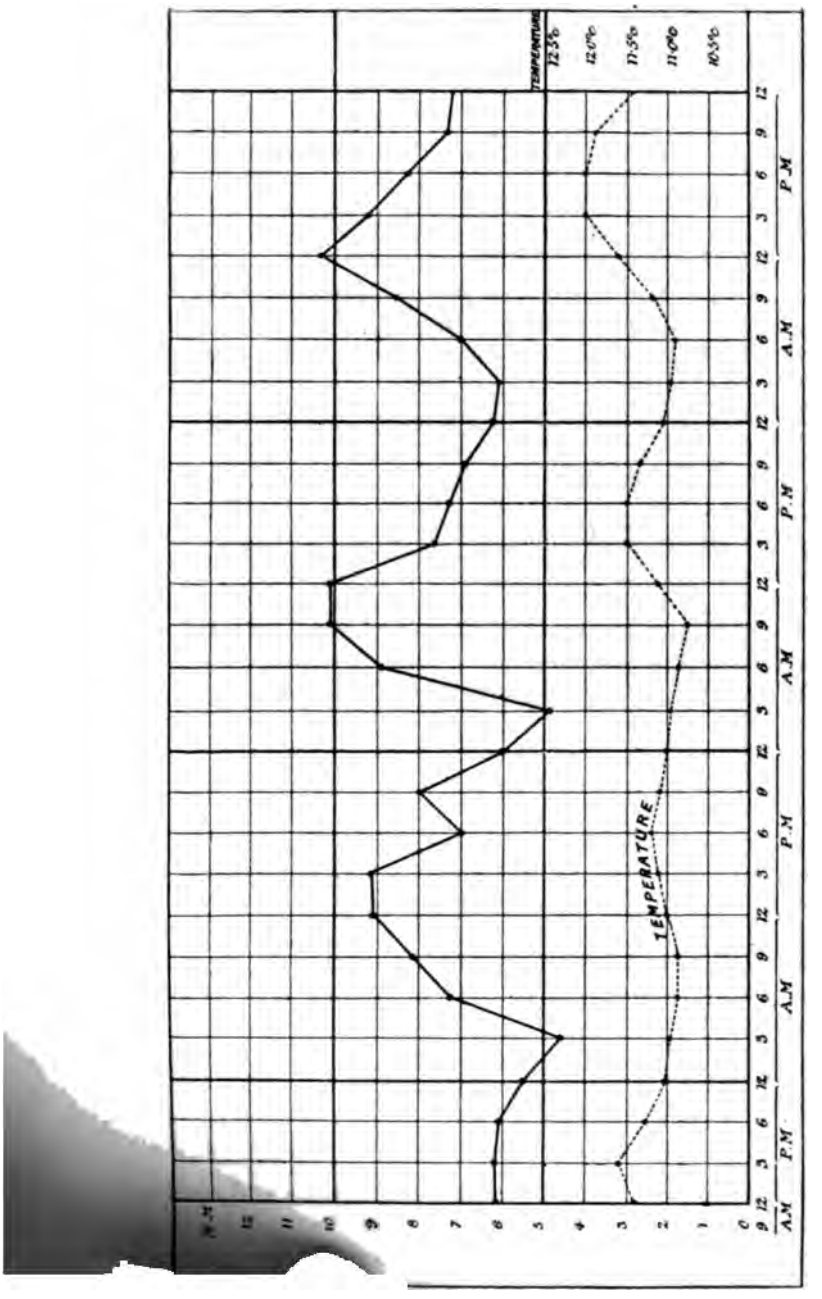
4. Give a short account of the structure and development of the fruit and seed in such a plant as the cherry or plum. Indicate and explain any important points of difference between such a seed, and that of a gooseberry or currant.

5. Sketch the life-history of a mushroom; emphasise and account for the structural differences between it and one of the higher plants.

6. Describe the structure and development of the moss sporogonium, and compare it briefly with that of Pellia.

7. Give some account of the sexual organs and fertilisation in Fucus and contrast the more important stages with the corresponding ones of Spirogyra.

8. Describe the sp
Equisetum.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Elementary Animal Biology.

MORNING PAPER.

FEBRUARY 12TH, 1903. 10 A.M. TO 1 P.M.

[FIVE *questions must be answered.*]

1. What is the lymphatic system? Explain its function and its relation to the blood system. State what you know of its occurrence in the Vertebrata.

2. Give a short account of the mechanism of respiration in a mammal and in a fish. Mention the more inportant nerve tracts concerned in the respiratory movements of a mammal.

3. State the principal features in which Amphioxus differ from the Vertebrata.

4. Give an account of the physical and chemical processes taking place during a muscular contraction.

5. What are the Anomodontia? Where are they found? To what living animals do they show affinity and in what respects?

6. Give an account of the Gastropod and Cephalopod shell, with especial reference to types of extreme modification and the chief developmental changes.

7. Give an account of the sympathetic nervous system of a mammal, describing its connection with the central nervous system. State your knowledge of its structure and function.

8. Describe the chief chemical and histological features of blood, and give an account of the phenomenon of coagulation. How and where do rejuvenescent blood cells arise?

9. State the characters which diagnose the class Aves and your knowledge of the Odontomithes and of Archæopteryx.

AFTERNOON PAPER.

12TH FEBRUARY, 1903. 2 TO 5 P.M.

[FIVE *questions must be answered.*]

1. Describe the renal organs of Lumbricus and compare them with those of Anodonta and A[illegible]

2. Describe and compare the [illegible] giving a full account of the [illegible] that of any Arth[illegible]

3. Describe the organ of hearing in any vertebrate and state its functions. What are the chief modifications undergone by the vertebrate "ear" and to what accessory organs may it give rise?

4. What are the Tunicata? Explain fully the reasons for regarding them as allied to the Vertebrata.

5. What are the Dipnoi, and what their salient characters?

6. State the chief anatomical peculiarities of the Mollusca, and the principal features which distinguish the three classes: Lamelli branchiata, Gastropoda, and Cephalopoda.

7. Give an account of the Nauplius, Trochophore, and Protrochal larvæ. State in what animals they occur, and discuss their significance.

8. Enumerate the characters of the chief groups of the Crustacea, and discuss their inter-relationships.

9. Describe the structure of any Flat Worm, with especial reference to the facts in which it differs from a Chætopod.

Metallurgy.

FEBRUARY 10TH, 1903.

Morning Paper. 10 A.M. TO 1 P.M.

INSTRUCTIONS.

You are not to attempt more than SIX *questions in this paper. The value attached to each question is the same. In describing processes, chemical reactions should be given whenever possible.*

1. Explain the principles of charcoal manufacture and illustrate your reply with a sketch of a charcoal pile.

2. Describe and make a sketch of a four hearth reverberatory calcining furnace.

3. Give a concise description of the extraction of gold by the cyanide process with particulars of the plant.

4. Describe and make a sketch of a pan with its furnace, suitable for parting gold and silver by sulphuric acid.

5. Describe the treatment of silver ores for the extraction of silver by pan amalgamation. Give examples of suitable and unsuitable ores for treatment.

6. How would you treat the following ore for the extraction of the lead which it contains? Give the reasons for your answer.

Galena - - -	72 per cent.
Zinc blende - -	12 ,, ,,
Iron pyrites - -	8 ,, ,,
Quartz - - -	8 ,, ,,

7. In prospecting you have met with a deposit of argentiferous lead ore; how would you make a *trial smelting of* 5 *or* 6 *cwt.* and afterwards cupel the lead to obtain the silver.

8. How would you treat a poor copper ore of the following composition for the extraction of its copper and silver

Copper pyrites - -	8 per cent.
Iron pyrites - -	30 ,, ,,
Calc spar -	[illegible]
Quartz -	
Silver, 5 ounces	

Metallurgy.—Theoretical Assaying.

FEBRUARY 10TH, 1903. 2 P.M. TO 5 P.M.

INSTRUCTIONS.

The Student is expected to give, whenever possible, the chemical reactions which take place in the processes he describes.

Not more than SIX *questions are to be answered.*

The value attaching to each question is the same.

1. How would you determine the value of a consignment of yellow copper ore?

State the methods you would adopt for sampling and assaying the material.

2. How would you take a sample for assay of the following materials:—

(*a.*) Tailings from a stamp battery during the daily work.

(*b.*) A pot of unrefined bullion from the zinc boxes of a cyanide plant.

(*c.*) A 1,000 oz. ingot of standard silver.

3. How would you assay a refractory slag for zinc?

4. How would you determine the amount of silver in a regulus containing 65 per cent. of copper? Give the reasons for adopting the methods you describe.

5. State briefly how the following substances are determined:—

(*a.*) Available cyanide in the liquors from the zinc boxes of a cyanide plant.

(*b.*) Gold in a cyanide solution.

(*c.*) Total amount of "protective alkali" in a cyanide solution.

6. How would you determine electrolytically the percentage of copper and nickel in a nickel copper alloy?

7. On what principles do the estimation of copper depend by

(*a*) the iodide method;

(*b*) the cyanide method.

State what substances interfere with the accuracy of the copper determination by each of the above methods.

ld you determine the iron in a sample

Practical Assaying.

FEBRUARY 12TH AND 13TH, 1903.

The examination of each student lasted for one day only, in which time he was required to perform one task from both of the following lists, the ores submitted being in each case of a simple character :—

LIST I. (DRY ASSAYS).

To determine the amount of

(1.) Gold in gold quartz ;
(2.) Silver in silver ore ;
(3.) Lead in galena or carbonate lead ore ;
(4.) Gold and silver in a triple alloy of gold, copper and silver ;
(5.) Coke that can be obtained from a coal.

LIST II. (WET ASSAYS).

To determine the amount of

(1.) Iron in an iron ore ;
(2.) Copper in copper carbonate ;
(3.) Copper in copper pyrites ;
(4.) Copper in an alloy ;
(5.) Zinc in blende.

The Dressing of Minerals.

(*For Metallurgical Students only.*)

10 A.M. TO 1 P.M. 14TH FEBRUARY, 1903.

(*a.*) *Answer the questions as far as possible in their numerical order.*

(*b.*) *It is desirable that the answers should be illustrated by sketches.*

(*c.*) *Neatness in answering the questions and in making the sketches is imperative.*

(*d.*) *Not more than* SIX *questions to be answered.*

1. Notice the fundamental relations between size and density of particles of minerals governing their free fall in water, and show how these relations are applied in dressing processes.

2. Describe some form of machine for breaking vein stuff for the stamp mill.

3. What is the Carr disintegrator, and what special use does it find in dressing minerals?

4. Under what conditions is hand-picking advantageous as a preliminary to crushing? Notice some method of applying it to a plant with a large output.

5. What is meant by coarse and fine crushing in stamp mills, and how are the weight, fall, and speed of stamp heads and the apertures of screens modified for either method?

6. Give the arrangement of a system of trommel sieves for sizing the intermediate products of crushing rolls for jigging machinery.

7. How can the separation of ores and waste be effected in materials that cannot be treated by motion in water?

8. Give a scheme for the dressing of tin stuff containing quartz, chlorite, mispickel, cassiterite, and wolfram.

Mathematics.

CLASS A.

JUNE 4TH, 1903. 10 A.M. TO 1 P.M

[A set of Mathematical Tables is supplied to each Candidate.]

Attempt EIGHT *questions only, four in each Section*

SECTION I.

1. Using contracted methods of multiplication and division compute

$$8{\cdot}123 \times 0{\cdot}2643 \text{ and } 0{\cdot}7705 \div 0{\cdot}02463,$$

giving the result in each case to four significant figures.

Compute $8{\cdot}123^{0{\cdot}6}$ and $0{\cdot}7705^{-0{\cdot}748}$ by aid of the tables.

Verify the statement

$$\tan\frac{\pi}{10}\tan\frac{3\pi}{10}=\frac{1}{\sqrt{5}} \qquad (12)$$

by aid of the tables.

2. $\frac{N}{M}=\epsilon\mu\theta, \qquad N-M=R.$

Determine M and N when $\mu=0{\cdot}7$, $\theta=\pi$, and $16\pi R=1100$.

(Note.—$\text{Log}_{10}\epsilon=0{\cdot}4343$.) (12)

3. Express in factors :—

(i.) $a^3+b^3+c^3-3abc$;

(ii.) x^4+x^2+1 ;

(iii.) $(x+1)(x+2)(x+4)(x+5)-4$;

(iv.) $a^4-7a^2b^2+b^4$. (12)

4. Simplify the following expressions :—

(i.) $\frac{x^{\frac{1}{2}}y^{\frac{3}{2}}}{\sqrt[3]{x^2y^3}} \div x^{\frac{1}{3}}y^{-\frac{1}{3}}$;

(ii.) $\frac{1}{(x^2+2x+1)(x+2)^2}+\frac{2x^2+7x+7}{(x+1)(x^2+4x+4)}-\frac{2}{x+2}$;

(iii.) $\sqrt{28-5\sqrt{12}}$. (12)

5. Solve the equations :—

(i.) $\left.\begin{aligned} ax+by&=a^2+b^2 \\ (a+b)\,x-(a-b)\,y&=0 \end{aligned}\right\}$.

(ii.) $(2x^2-x)^2-4x^2+2x=3$.

(iii.) $2\sqrt{3x+7}=7+\sqrt{2x-3}$. (12)

6. The distance of the visible horizon at sea in *miles* varies as the square root of the height of the eye in *feet* above the sea-level, and the distance is 3 miles when the height of the eye is 6 feet. Find the distance when the height is 150 feet. (12)

7. Find to three significant figures a value of x which satisfies the equation

$$2x^2-10\log^{10}x-3{\cdot}25=0. \qquad (12)$$

8. Try whether the relation between the values of p and v given in the following table is fairly well represented by the equation

$$pv^k=\text{constant},$$

and if this proves to be the case, determine the value of k.

p	4·46	4·11	3·78	3·44	3·19	2·96	2·67
v	3·34	3·73	4·12	4·6	5·08	5·58	6·3

Find the value of p when $v=3{\cdot}9$. (14)

Section II.

9. Prove that

$$\sin 15^\circ=\frac{\sqrt{6}-\sqrt{2}}{4}.$$

Determine the cosine and tangent of 15° expressed in surds in their simplest form and their numerical equivalents to three places of decimals.

Take out from the table of angles supplied the sine, cosine, and tangent of the following angles :—

24°, 114°, 204°, 294°, 384°. (12)

10. Prove that the distance of the sun is nearly 81 million geographical miles, when 8″·76 is half the angle which the earth subtends at the distance of the sun, a geographical mile subtending 1′ at the earth's centre. (12)

11. Prove the formulæ:—

(i.) $\cos C - \cos D = -2 \sin \frac{C+D}{2} . \sin \frac{C-D}{2}$.

(ii.) $\sqrt{\left(\frac{1-\sin 2A}{1+\sin 2A}\right)} = \tan (45° - A)$. (12)

12. Show that

(i.) $\sin 80° = \sin 40° + \sin 20°$.

(ii.) $\sin 70° = \sin 10° + \sin 50°$.

(iii.) $\tan (30° + a) \tan (30° - a) = \frac{2 \cos 2a - 1}{2 \cos 2a + 1}$. (12)

13. The sides of a triangle, 35, 48, and 51 feet; determine the angles.

Find the area of this triangle to the nearest square foot. (12)

14. A ship sailing due North observes two lighthouses in a line due West; and after an hour's sailing the bearings of the lighthouses are observed 44° and 21° West of South. The distance between the lighthouses being 8 miles, find the rate at which the ship is sailing. (12)

15. A body has passed through s feet measured from some zero point in its path at the time t seconds measured from some zero of time. The law of motion is $s = 12{\cdot}2 - 3{\cdot}4t + 6{\cdot}7t^2$. Calculate s for each of the following values of t:—4, 4·1, 4·01, and 4·001, and thence find the average velocity, (i) for the first tenth of a second, (ii) for the first hundredth of a second, and (iii) for the first thousandth of a second after the instant when $t = 4$.

What is the actual velocity when $t = 4$? (14)

16. Given $y = ax^5$, $y = bx^n$, $y = \sin x$; find in each case the value of $\frac{dy}{dx}$.

Write down the values of

$\frac{d (\sin ax)}{dx}$, $\frac{d (\cos bx)}{dx}$, $\int x^n dx$, $\int x^{-1} dx$ and $\int \cos ax \, dx$.

(12)

Class B.

June 4th, 1903. 10 a.m. to 1 p.m.

1. Find the equation of a straight line in the form

$$x \cos a + y \sin a - p = 0.$$

Given two points P (4, 2) Q (3, 5), find the distance of P from the line

$$3x - 5y + 7 = 0,$$

and show that the straight line PQ is bisected by this line.

2. Two straight lines are drawn from (h, k) one parallel to the line

$$5x - 7y + 6 = 0$$

and the other perpendicular to it; give their equations.

A (4, 0) B (5, 7) C (0 5) are three of the vertices of the parallelogram $ABCD$. Find the co-ordinates of D, and the length of the diagonal BD.

3. Find the equation of a circle referred to rectangular co-ordinates, its centre being at (a, b) and c being its radius.

A point P moves so that the lengths of the tangents drawn from P to the two circles

$$x^2 + y^2 - 4 = 0$$

and $$x^2 + y^2 - 8x + 6y - 11 = 0$$

are equal.

Show that P lies on a certain fixed straight line, which is perpendicular to the line joining the centres of the circles.

4. Having given the equation of a parabola $y^2 = 4ax$, find the equation of the tangent at the point x', y'.

If Y be the foot of the perpendicular drawn from the focus to any tangent, show that Y lies on the tangent at the vertex of the parabola.

For what value of c will the line $3y - 2x + c = 0$ touch the given parabola.

5. Indicate in a figure the form of the curve given by the equation $4x^2 + 9y^2 = 36$.

Find the length of its axes, its eccentricity, and the position of its foci. Show that the sum of the focal distances of any point on the curve is constant.

A straight line AB of length 16 inches moves with its extremities on two fixed straight lines OC, OD, which are at right angles. Show that a point P on AB will in general describe an ellipse. Find the position of P to trace out an ellipse of eccentricity $\frac{1}{2}$.

6. Define the asymptotes of a hyperbola, and mark them in the case of the hyperbola

$$4x^2 - 9y^2 - 36a^2 = 0.$$

If the normal at P, a point on the rectangular hyperbola

$$x^2 - y^2 = a^2$$

meet the axes at G, G^1, and QQ^1 is the diameter parallel to GG^1; prove $GG^1 = QQ^1$.

7. Interpret geometrically the following equations:—

(1.) $2x^2 + 5xy + 2y^2 - 3(x + y) + 1 = 0.$
(2.) $5x^2 + 8xy + 5y^2 - 6(x + y) + 2 = 0.$

8. Show that

$$lx + my + nz - p = 0$$

is the equation of a plane where p is the length of the perpendicular from the origin to the plane, and (l, m, n) its direction-cosines.

A plane is drawn through the point P (5, 4, 2) parallel to the plane

$$3x + 5y + 2z - 7 = 0.$$

Find the lines in which the former plane meets the co-ordinate planes, and give the distance between the parallel planes.

9. If (l, m, n) (l^1, m^1, n^1) are the direction-cosines of two straight lines, and θ be their inclination to one another, prove that

$$\cos\theta = ll^1 + mm^1 + nn^1.$$

Find the angle between the lines

$$\frac{x + 7}{2} = \frac{y - 3}{4} = \frac{z - 2}{5}$$

and

$$\frac{x + 2}{3} = \frac{y - 8}{1} = \frac{z - 9}{2},$$

and show that these lines intersect each other.

Class B.

JUNE 4TH, 1903. 2 P.M. TO 5 P.M.

1. Graph the function x^3, also the function $7x + 6$, between $x = -5$ and $x = 5$.

Solve graphically, or by calculation, the cubic equation

$$x^3 - 7x - 6 = 0,$$

2. Apply the binomial theorem to give the co-efficients of x^3 and of x^4 in the expansions of $(2 + x)^{\frac{3}{2}}$, and of $\left(\frac{1}{x} + x\right)^{-3}$ in ascending powers of x.

Give the co-efficient of x^r in the expansion of $(1 - x)^{-n}$.

If x be a proper fraction, show that

$$(1 + x + x^2 + x^3 + \ldots \text{ to inf.})^2 = 1 + 2x + 3x^2 + 4x^3 + \ldots + (r+1)x^r + \ldots \text{ to inf.}$$

3. Find the sum of n terms of the series

$$1^2 + 2^2 + 3^2 + 4^2 + \ldots$$

Also find the sum of n terms of the series of which the rth term is $(r^3 - 2r^2 + 4)$.

4. Resolve into partial fractions

$$\frac{3x + 2}{(2x + 5)(7x - 1)}, \quad \frac{x}{(x^2 - 9)(x + 2)},$$

$$\frac{2x + 1}{(x^2 + 9)(2x^2 + 1)}.$$

5. Find the sum of n terms of the following series :—

(1.) $\sin \alpha + \sin(\alpha + \beta) + \sin(\alpha + 2\beta) + \sin(\alpha + 3\beta) + \ldots$

(2.) $\cos \alpha - \cos 2\alpha + \cos 3\alpha - \cos 4\alpha + \ldots$

6. Show that the value of a determinant is zero if two lines are identical, or if two columns are identical.

Calculate the value of the determinants

$$\begin{vmatrix} 3 & 1 & 7 \\ 2 & 5 & 1 \\ 4 & 2 & 4 \end{vmatrix} \qquad \begin{vmatrix} 1 & 2 & 5 & 7 \\ 2 & 0 & 1 & 2 \\ 3 & 1 & 1 & 4 \\ 6 & 2 & 6 & 1 \end{vmatrix}$$

7. Show that the continued product of n factors each of which is $(\cos\theta + i \sin\theta)$ is equal to $(\cos n\theta + i \sin n\theta)$.

Deduce an expression for $\sin n\theta$ in terms of powers of $\sin\theta$ and $\cos\theta$, and give the value of 5θ.

8. Differentiate from first principles x^4 and $\sin x$.

In the curve $y = \sin x$, what is the gradient of the curve when $x = \frac{\pi}{6}$? Draw the normal to the curve at this point.

For what value of θ is $\tan\theta$ increasing four times as fast as θ is increasing?

9. A sector of a circle bounded by two radii including an angle of 30° revolves about one of these radii, which is fixed. Find the area of the portion of spherical surface generated, and the volume swept through by the revolving area.

10. Find the value of the integrals

$$\int_a^b x^n \, dx, \quad \int_{\frac{\pi}{4}}^{\frac{\pi}{3}} \sin x \, dx$$

Find the area included between the parabola $x^2 = 9y$ and the line $y = x$.

CLASS C.

JUNE 5TH, 1903. 10 A.M. TO 1 P.M.

1. Prove the rule for differentiating the product $F(x)$ $f(x)$ with respect to x.

Find $\frac{dy}{dx}$ in the following cases:—

(1.) $y = \frac{a - x}{\sqrt{a^2 + x^2}}$.

(2.) $y = \log\left(\frac{\sqrt{3} + \tan x}{\sqrt{3} - \tan x}\right)$.

2. Explain the method of finding maximum and minimum values of (x), and show how to discriminate between them.

Find maximum and minimum values of $3x\sqrt{5x - 10}$.

If $y = A \tan \theta$, where θ is an observed angle, show that for a given constant error in reading θ, the percentage error in the calculated value of y is least when $\theta = \frac{\pi}{4}$.

3. Give an elementary proof of Maclaurin's theorem for expanding $f(x)$ in ascending positive integral powers of x, assuming such an expansion possible.

Give the expansion of $\cos^2 x$, and of $\tan x$ correct as far as terms involving x^6 inclusive.

4. How is the differential calculus applied to investigate the limiting values of

$$\frac{f(x)}{\phi(x)}$$

when x approaches indefinitely near to the value $x = a$, if $f(a) = 0$, and $\phi(a) = 0$.

Find by any method the limiting values when $x = 0$ of

(1.) $\dfrac{e^{2x} - 2 + e^{-2x}}{x^2}$,

(2.) $(\cos x)^{\cot x}$.

5. Find the equation of the tangent and of the normal at any point (h, k) on the curve whose equation is given in the form $y = f(x)$ or $F(x, y) = 0$.

Write down the equation of the normal to the curve

$$2x^2 + 7xy + 3y^2 - 5x - 5y - 118 = 0,$$

at the point (2, 5).

In the curve

$$3y^2 - (x + 1)^3 = 0,$$

show that the sub-normal varies as the square of the sub-tangent.

6. Define the curvature at any point on a curve, and explain how it is measured.

Show that in the rectangular hyperbola $xy = c^2$, the radius of the curvature varies as the cube of the distance of the point from the centre of the curve.

7. What is a rectilinear asymptote? What is the greatest possible number of real asymptotes to a cubic curve? Find the asymptotes of the curve

$$xy(x + y - 1) = 5x + 2y - 3,$$

and draw it.

8. Show that the envelope of the family of curves $f(x, y, a) = 0$ where a in a variable parameter touches each member of the family.

Circles are described on double ordinates of the parabola $y^2 = 4ax$ as diameters; show that their envelope is an equal parabola.

9. A straight line passes through the points (3, 1, − 5) (5, 4, − 6). A second line passes through (1, 1, 2) and is perpendicular to the plane

$$2x + y - 3z - 6 = 0.$$

Find the length of the shortest distance from one line to the other.

10. Indicate, with diagrams, the form of the surfaces

(1.) $5x^2 + 2y^2 + 4z^2 = 1$

(2.) $5x^2 - 2y^2 - 4z^2 = 1$

Showing the nature of the sections made by the co-ordinate planes.

Find the area and the lengths of the axes of the section of

$$5x^2 + 2y^2 + 4z^2 = 1$$

by the plane

$$2x + 3y + z = 0.$$

CLASS C.

JUNE 3RD, 1903. 2 TO 5 P.M.

1. If z be a function of two independent variables x, y, explain clearly what is meant by the partial differential coefficients

$$\frac{\partial z}{\partial x}, \quad \frac{\partial z}{\partial y},$$

and the total differential dz, and give some illustration.

What is the test which must be satisfied in order that $Pdx + Qdy$ may be an exact differential? Apply the test to the expression

$$(12x^2y^2 + 3x^2 - 10xy - 8y + 3)dx + (8x^3y - 5x^2 + 18y - 8x)dy.$$

2. If $\phi(x)$ be a finite continuous function of x between $x = a$ and $x = b$, show that the limit of the sum of the series

$$h[\phi(a) + \phi(a + h) + \phi(a + 2h) + \ldots + \phi(b)]$$

when h is indefinitely diminished is

$$F(b) - F(a),$$

where

$$\frac{dF(x)}{dx} = \phi(x);$$

give the geometrical interpretation.

Find

$$\int_2^4 \sqrt{x} \cdot (2 + 3x)^2 dx.$$

3. Find the following integrals :

$$\int \frac{8x-5}{2x^2+x-1}dx, \quad \int \sqrt{\frac{3-4x}{3+4x}}.dx, \quad \int \frac{d\theta}{2-\cos\theta}.$$

4. Show how to connect

$$\int \sin^{r}\theta \,.\, \cos^{q}\theta \,.\, d\theta$$

with

$$\int \sin^{p}\theta \,.\, \cos^{q-2}\theta d\theta,$$

and obtain a formula of reduction. Find the values of

$$\int_0^{\frac{\pi}{4}} \frac{\sin^{6}\theta}{\cos^{4}\theta} d\theta$$

and

$$\int_0^{\frac{\pi}{4}} \frac{\sin^{5}\theta}{\cos^{4}\theta} d\theta.$$

5. Find the (radius of gyration)^2 of a circular disc about an axis through its centre perpendicular to its plane.

Find also the (radius of gyration)^2 of an uniform solid cone about its axis.

6. Find the area of that part of the ellipse

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$$

which lies within the parabola $b^2x^2=(a^2-b^2)ay$.

Find also the area of a loop of the curve $r = a \sin 3\theta$.

7. Show how to find the length of an arc of the curve $y = f(x)$

Trace the curve $9y^2 = (x+7)(x+4)^2$ and find the perimeter of the loop.

8. Solve the following differential equations :

(1.) $(x^2+xy)\frac{dy}{dx}+y^2=0.$

(2.) $\frac{dy}{dx}+2xy=1+2x^2.$

(3.) $y - x\frac{dy}{dx} - \sqrt{1+4\left(\frac{dy}{dx}\right)^2}=0,$

and give the singular solution in (3).

9. Solve

(1.) $\frac{d^2y}{dx^2} + 5\frac{dy}{dx} - 14y = 4 \sin 3x.$

(2.) $\frac{d^3y}{dx^3} - 5\frac{d^2y}{dx^2} + \frac{dy}{dx} - 5y = 4e^{2x} + x + 2.$

CLASS D.

JUNE 4TH, 1903. 10 A.M. TO 1 P.M.

1. Show that

$$\int_0^1 x^{m-1}(1-x)^{n-1}\,dx = \Gamma(m)\,.\,\Gamma(n) \;/\; \Gamma(m+n)$$

where

$$\Gamma(m) = \int_0^\infty e^{-x} x^{m-1} dx.$$

Show also that

$$\Gamma(n) = (n-1)\,\Gamma(n-1).$$

2. Prove Gauss' thereom that the surface integral of the attraction exerted by any distribution of matter in the direction of the inward normal at every point of any closed surface is 4π times the amount of matter within the surface.

What is the hydrokinematic interpretation ?

Deduce Poisson's equation

$$\nabla^2 V + 4\pi\rho = 0,$$

where V is the potential and ρ the density of the matter.

3. Solve two of the following differential equations:—

(i.) $\left(\frac{dy}{dx}\right)^2 = \frac{1-y^2}{1-x^2}.$

(ii.) $(1+x^2)\frac{d^2y}{dx^2} + 1 + \left(\frac{dy}{dx}\right)^2 = 0.$

(iii.) $y(1-\log y)\frac{d^2y}{dx^2} + (1+\log y)\left(\frac{dy}{dx}\right)^2 = 0.$

4. Obtain the general solution of the equation

$$\frac{d^2y}{dt^2} + 2k\frac{dy}{dt} + n^2y = U$$

in the form

$$y = e^{-kt}(A \cos n't + B \sin n't) + \frac{1}{n'}\int_0^t e^{-k(t-t')} \sin n'(t-t')\, U'\, dt',$$

where U' is the same function of t' as U is of t, and n' is given by

$$n'^2 = n^2 - k^2.$$

5. Find a solution of the equation

$$\frac{d^3y}{dx^3}+\frac{1}{x}\frac{d^2y}{dx^2}-\frac{1}{x^2}\frac{dy}{dx}=x+\frac{1}{x},$$

subject to the conditions that $y=0$ when $x=a$, and that $\frac{dy}{dx}=0$ both when $x=0$ and when $x=a$.

6. Find the condition that the total differential equation

$$P\,dx+Q\,dy+R\,dz=0 \quad . \quad . \quad . \quad . \quad (1)$$

admits of an integrating factor; and if the condition be fulfilled, prove that (1) represents the family of surfaces which cut the curves

$$\frac{dx}{P}=\frac{dy}{Q}=\frac{dz}{R}$$

orthogonally.

Solve the equation

$$(2x^2+2xy+2xz^2+1)\,dx+dy+2z\,dz=0.$$

7. Find expressions in terms of zonal harmonics for the potential of a thin uniform circular disc, at any external point, the density of the disc being ρ, its thickness k, and radius a.

8. If dA denote an element of a plane area, and ds an element of length of its closed contour, show that

$$\iint\left(\frac{\partial Y}{\partial x}-\frac{\partial X}{\partial y}\right)dA=\int\left(X\frac{dx}{ds}+Y\frac{dy}{ds}\right)ds$$

where X and Y are functions of the co-ordinates (x, y).

The complex variable $x+iy$ being denoted by z, and $f(z)$ being finite and continuous throughout an area surrounding the point $z=a$, show that

$$\int f(z)\,dz=0, \quad \int\frac{f(z)}{z-a}\,dz=2\pi i\,f(a),$$

the integrals being taken round any simple closed curve in the area so as to enclose the point a.

9. Solve the equations

(i) $\frac{\partial^2 z}{\partial x^2}+\frac{\partial^2 z}{\partial y^2}=\cos mx\cos ny.$

(ii) $x^2\frac{\partial^2 z}{\partial x^2}-y^2\frac{\partial^2 z}{\partial y^2}=xy.$

10. Write down Fourier's series for expanding $f(x)$ in sines and cosines of multiples of x from $x=-c$ to $x=c$, and express the coefficients as definite integrals.

Deduce that

$$f(x) = \frac{1}{\pi}\int_{-\infty}^{\infty} f(u)\,du \int_0^{\infty} \cos v\,(u-x)\,dv.$$

11. Working from the equations on p. 371 of the text-book supplied, with the assumption that $R=0$, find the differential equation, giving the displacement of any point of the middle surface of a circular plate loaded uniformly and with a concentrated load at the centre and supported or fixed at the rim.

12. With reference to the article on the torsion of a shaft whose section is an equilateral triangle on p. 377 of the text-book supplied, complete the solution and show that the shear is zero in the corners, and is a maximum at the middle of the sides.

CLASS D.

JUNE 4TH, 1903. 2 P.M. TO 5 P.M.

1. Establish Green's transformation of a volume integral into a surface integral and deduce Green's Theorem.

Assuming equations (1) p. 364 of the Text-book supplied, deduce equations (2) by means of the transformation established.

2. Find the values of the following definite integrals :—

$$\int_0^{\infty} e^{-x^2}dx,\quad \int_0^{\infty} e^{-a^2 x^2}\cos bx\,.\,dx,\quad \int_0^{\infty} e^{-ax}\cos bx\,dx$$

3. In the equation

$$\frac{d^2v}{d\theta^2} + v = P\cos\theta - T(1-\sin\theta) - C.$$

P is a known constant, T and C unknown constants which have to be determined, together with the constants of integration, by aid of the conditions :—

(1.) $v = 0$ when $\theta = 0$;

(2.) $\int_0^{\frac{\pi}{2}} v\,d\theta = 0$;

(3) $\frac{dv}{d\theta} = 0$ both when $\theta = 0$ and when $\theta = \frac{\pi}{2}$.

Show that

$$T = \frac{8-2\pi}{\pi^2-8}P, \text{ and } C = \frac{4\pi-12}{\pi^2-8}P.$$

4. Solve the following equations :—

(i) $$\begin{cases} \frac{dx}{dt} + 5x + y = e^t \\ \frac{dy}{dt} - x + 3y = e^{2t} \end{cases}$$

(ii) $$\begin{cases} \frac{d^2x}{dt^2} - 3x - 4y = 0. \\ \frac{d^2y}{dt^2} + x + y = 0. \end{cases}$$

5. Integrate in series of ascending powers of x the differential equation

$$2x^2 \frac{d^2y}{dx^2} - x\frac{dy}{dx} + (1 - x^2)\, y = 4x^2 + 5.$$

6. Establish a rule for solving the linear partial differential equation of the first order

$$Pp + Qq = R.$$

Solve the equation

$$(11x - 6y + 2z)p - (6x - 10y + 4z)\, q = 2x - 4y + 6z.$$

7. Solve the following partial differential equations :—

(i) $x^2p^2 + y^2q^2 = z.$
(ii) $z = px + qy + pq.$
(iii) $p^2 + q^2 = x + y.$

8. If $P_n(x)$ denotes the zonal surface harmonic of the nth order, show that :—

(1.) $$\int_{-1}^{1} P_m(x) \,.\, P_n(x)\, dx = 0.$$

(2.) $$\int_{-1}^{1} \left[P_n(x)\right]^2 dx = \frac{2}{2n+1}.$$

(3.) $$\int_{1}^{1} x^n P_n(x)\, dx = \frac{1 \,.\, 2 \,.\, 3 \,.\, \ldots \,.\, n}{1 \,.\, 3 \,.\, 5 \,\ldots\, (2n+1)}.$$

9. Find a solution of the equation

$$\frac{\partial u}{\partial t} = a^2 \frac{\partial^2 u}{\partial x^2}$$

which satisfies the conditions that $u = f(x)$ when $t = 0$, and $u = \phi(t)$ when $x = 0$.

10. In the treatment of the St. Venant prism problem in the Text-book supplied, p. 373, line 14, find the values of, u_0, u_1, v_0, v_1, and show that $\beta = 0$.

11. Obtain the differential equation

$$\frac{\partial^2 y}{\partial t^2} = a^2 \frac{\partial^2 y}{\partial x^2}$$

for the transverse vibration of a stretched string in the xy plane.

If the ends be fixed at a distance l apart, and a point distant b from one end be initially displaced transversely an amount γ, find the form of the string at any subsequent time.

CLASS E.

JUNE 11TH, 1903. 10 A.M. TO 1 P.M.

1. Prove Kelvin's theorem that if impulses are applied to a system only at places where the velocities to be produced are prescribed, the kinetic energy is less in the actual motion than in any other motion which the system can take, and which has the same values for the prescribed velocities.

A regular hexagonal framework formed of six freely jointed uniform bars lies on a smooth table; show that if the mid point of one bar is made to move with velocity v in the line through the centre of the framework, the opposite bar begins to move with velocity $v/10$.

2. Two uniform rods, each of weight W, connected by a hinge which allows them to move in a vertical plane, rotate about a vertical axis through the hinge, and a light thread whose length, $2l$, is twice that of either rod, is fastened to their extremities and bears a weight W' at its middle point. Find the angular velocity about the vertical axis which will maintain the rods and thread in a form of a square, and supposing the weight W' now slightly depressed, find the period of a small oscillation.

3. Find expressions for the rate of change of the components of a vector quantity referred to rectangular axes moving in any manner about a fixed point.

Deduce Euler's dynamical equations of the form

$$A\dot{\omega}_1 - (B-C)\omega_2\omega_3 = L.$$

5. A uniform cube of mass M has one of its diagonals vertical and is free to rotate about it; a particle of mass m is tied to the top corner of the cube by a

fine string of the same length as an edge of the cube. Initially the string is tight along one edge of the cube, and the particle is then slightly displaced along an adjacent face; find the tension of the string when the particle passes through its lowest position in that face of the cube.

5. Establish Lagrange's equations of motion of the type

$$\frac{d}{dt}\left(\frac{T}{\partial\dot{\theta}}\right)-\frac{\partial T}{\partial\theta}=\Theta$$

for a system of rigid bodies referred to generalised co-ordinates.

The mass ρl of a string stretched with tension T_1 being supposed concentrated into n particles at equal distances apart, and the ends of the string being kept fixed at a distance l apart, find the periods of the normal modes of transverse vibration of the system.

6. A rigid body is turning with angular velocity ω about an axis whose six co-ordinates are $l, m, n, \lambda, \mu, \nu$, referred to the principal axes at the centre of gravity. Suddenly this axis is released and a new axis fixed whose co-ordinates are $l', m', n', \lambda', \mu', \nu'$; find the new angular velocity.

7. Form the equations of motion of a symmetrical top moving about a fixed point, and show from them that the precessional motion changes its direction if the position of the C. of G. of the top be altered from above to below the point of support. Show also that the maximum value of the velocity of precession is

$$2Mgl/C\omega_3$$

in the usual notion.

8. Suppose a rough hollow cylinder fixed in space with its axis vertical, and that a sphere is projected in rolling contact inside with a horizontal velocity $(c-a)\omega$, where c is the radius of the cylinder and a the radius of the sphere.

Show that the vertical displacement of the centre of the sphere after t seconds is

$$\frac{5g}{2\omega^2}\left\{1-\cos\left(\omega t\sqrt{\tfrac{2}{7}}\right)\right\}.$$

Mechanics.

Parts II. and III.—First Paper.

JUNE 8TH, 1903. 10 A.M. TO 1 P.M.

Only SIX *questions to be answered.*

1. A roof truss has the form shown in the giv[illegible]en diagram, and it is loaded as is there indicated. Det[illegible]er-mine and state the forces in any six members of t[illegible]he frame. (1[illegible]6)

2. A beam, loaded uniformly throughout its length, [illegible]is supported at one extremity and at some other poi[illegible]nt. Show that the beam will carry the greatest load wi[illegible]th safety when the second support divides the beam in [illegible]to segments having a ratio of $1 : (\sqrt{2}-1)$. (1[illegible]6)

3. The span of the girders in an overhead travelli[illegible]ng crane is 40 feet, and the distance apart of the wheels o[illegible] the crab 6 feet, the loads on the two wheels bein[illegible]g respectively 5 and 8 tons.

Draw diagrams giving the maximum shearing force an[illegible] maximum bending moment throughout the girder due t[illegible] this travelling load. Measure the maximum bendin[illegible]g moment. (1[illegible]

4. A plate web girder with parallel flanges is 60 fe[illegible] span, 5 feet deep, and the width of the flanges is 21′ The load carried is $1\frac{1}{2}$ tons per foot run, and the stres[illegible] induced has not to exceed 4 tons per square inch. If th[illegible] angle irons be $4\frac{1}{2}'' \times 4\frac{1}{2}'' \times \frac{1}{2}''$ and the diameter of th[illegible] rivets be 1″, estimate the necessary thickness of the flange[illegible] at the centre section; and if one of the flange plates be $\frac{1}{2}''$ thick and "break joint" at the centre of the span, estimate the length of the cover plate—the riveting being arranged zig-zag, the pitch of the rivets 4″ and the safe shear stress of the rivets 4 tons per square inch. Indicate how the lengths of the different flange plates are determined. (16)

5. A vertical wire, $34\frac{3}{4}''$ long and ·1225″ diameter, is clamped at its upper end and carries a horizontal rod at its lower end. Two weights, each 3 lbs., can be fastened to the rod in any positions. When the distance of each weight from the axis of the wire is $4\frac{1}{8}''$ it is found that the frequency of the natural torsional oscillations is 42·3 a minute; when the distance is $2\frac{1}{8}''$, the frequency is 69·8. Estimate the coefficient of rigidity of the wire. (16)

6. A built-up gun is 8″ diameter bore, and the external diameter of the second tube is 17·4″. The internal diameter of the third tube is less than this by ·0135″, and is slipped over the second tube by raising its temperature sufficiently. Estimate (1) the necessary rise in temperature of the third hoop, and (2) the *difference* in hoop stress between the external layer of the second tube and the internal layer of the third tube due to shrinkage—having given that the coefficient of linear expansion of steel is $\frac{1}{180000}$ per degree Fahrenheit, that Young's modulus for steel is 12,500 tons per square inch, and assuming that the longitudinal stress in the gun is constant over a section. (18)

7. A spiral spring carries a weight of 6·83 lbs. When making free vertical oscillations it is found that the periodicity of the oscillations is 1·46 seconds, and two successive amplitudes ·094 feet and ·0855 feet. Estimate the force per unit extension of the spring, and, assuming that resisting force is equal to the velocity multiplied by some coefficient, find the value of that coefficient. (16)

8. Three derrick poles are jointed at the apex. The points A, B, C, where the poles touch the ground form the corners of a triangle, such that the lengths of the sides AB and AC are 25 and 30 feet long respectively, and the contained angle is 120°. The pole A is vertical and 30 feet high, and the jib can turn about A. The plane of the jib and pole makes an angle of 30° with AC and 90° with AB, and the line of action of the load is 20 feet from the pole A. Find the vertical forces at the points A, B, C, and the forces in the poles B and C when the load carried is 10 tons. (16)

9. A continuous metal rib is hinged at each springing and the span remains unaltered in length under all loads. Explain how you would determine the horizontal thrust, and how you would draw the bending-moment diagram for the arch for any system of vertical loading. (16)

10. A vessel containing water and having a circular orifice, one inch in diameter, in one of its sides, is supported in such a way that when a jet of water issues from the orifice the resultant force on the vessel can be very accurately measured. With a constant head of water of $2\frac{1}{4}$ feet above the centre of the orifice, the force on the vessel was found to be ·9 lb., and the discharge $15\frac{1}{2}$ gallons per minute. Determine the coefficients of discharge. (16

11. Investigate the motion of a projectile in a non-resisting medium, and determine the direction of projection for maximum range on the horizontal plane through the point of projection.

Prove the approximate rule that four times the square of the number of seconds in the time of flight in a range on a horizontal plane is the height in feet of the highest point of the trajectory. (16)

12. Find expressions for the radial and the transverse accelerations of a particle which moves in a plane curve.

A particle describes an ellipse under the action of an attracting force at a focus. Show that the law of force is that of the inverse square of the distance. (16)

Parts II and III. Second Paper.

JUNE 8TH, 1903. 2 P.M. TO 5 P.M.

Only SIX *questions to be answered.*

1. Describe a laboratory experiment for measuring the supporting forces of a rectangular beam of timber, when carrying a number of weights and supported at three places.

Explain how you would verify your results by graphical or numerical computation. (16)

2. A three-hinged braced roof is as shown. Explain how you would proceed to find the supporting forces and the longitudinal forces in the several members when the roof is loaded with weights at each joint of the upper flange. (16)

3. Explain how the principle of work is applied to the determination of the forces in a jointed plane frame which has redundant members.

Three iron rods are pinned together at their lower ends, and their upper ends are attached to an overhead beam. The middle rod is vertical, and bisects the angle between the other two, which are each inclined at 45°. If a load were suspended from the rods, what fraction of the load would the vertical rod carry, all three rods being of equal cross-sectional area? (18)

4. The crank shaft of a three-cylinder engine is supported on four equidistant bearings, and the centre section of each crank is midway between its bearings. The stroke of the pistons is 4 feet, the common pitch between the bearings 6 feet, the cranks are set at 120° with each other, and the twisting moment only may be considered as transmitted from cylinder to cylinder, or, in other words, each segment of the shaft may be looked upon as a separate beam. When the aftermost crank arm is horizontal, the vertical force on each pin is 20 tons. If the diameter of the aftermost crank pin be 17″, find the maximum direct and maximum shear stresses induced in it. (16)

5. A uniform raft of rectangular section, which when floating freely is immersed to two-thirds its depth, has one end stranded so that the lower edge of that end is in the plane of flotation (as in the figure). If the ends be assumed vertical in the position of equilibrium, show that (I) the upper edge of the sea end is also in the plane of

flotation, (2) that the pressure on the wall is $\frac{W}{4}$, (3) that the maximum bending moment on the raft is $\frac{Wl}{27} - W$ being the weight of the raft and l its length. (16)

6. The outboard propeller shaft of a torpedo boat destroyer is l feet long between the centres of the stern tube and after-bracket bearings, and the thrust of the propeller is P lbs. Show that if the bearings be taken to exercise no bending constraint on the shaft; that is to say, if the bending moments at the two bearings is

zero, the angular velocity ω at which the shaft will whirl is given by

$$l^2\left\{\sqrt{\frac{\sigma\omega^2}{gEI}+\frac{P^2}{4E^2I^2}}+\frac{P}{2EI}\right\}=\pi^2$$

in which I is the geometrical moment of inertia of the shaft about a diameter and E Young's modulus for the material of the shaft, and σ the weight of the shaft per foot run. State, in general terms, how the mass of the propeller would modify the problem. (18)

7. If a long thick cylinder be subjected to internal and external pressures, show that the radial and hoop pressures (p and q) at radius r are given by the equations

$$p=b+\frac{a}{r^2}$$

$$q=b-\frac{a}{r^2}$$

where a and b are constants. State precisely the assumptions you have made and, if you have not had occasion to assume it, show that the cylinder is truly cylindrical in the strained state. (16)

8. Explain how reversal of thrust on the crank pin brasses is prevented in Willan's high-speed engine.

In such an engine the diameter of the air cylinder is 12″, the diameter of the air trunk 8″, the stroke 6″ and the length of the connecting rod 12″. Assuming the air in the compression cylinder to follow the hyperbolic law, and that when the piston is at the bottom of the stroke the pressure in the cylinder is atmospheric, estimate the clearance required at the top of the cylinder in order to just balance the inertia pressure of the reciprocating parts—the weight of the reciprocating parts being 800 lbs. and the revolutions 400 per minute. (16)

9. A vertical column of length l is fixed vertically in the ground at its bottom end but is quite free at its top end. A bracket is attached to the top, and carries a weight W at its extremity. The column consequently bends over. Show that, due to this flexure, the bending moment at the base of the column is increased in the ratio

$$\sec\sqrt{\frac{W}{EI}}.l$$

whatever the length of the bracket—where E and I have their usual meanings. (16)

10. A load W, if applied slowly, induces an intensity of strees f_0 in a bar of length l. Show that (provided the limits of elasticity be not exceeded) if the same load fall a height h before extending the bar, the maximum stress induced is given by

$$f_0\left\{1+\sqrt{1+\frac{2Eh}{f_0 l}}\right\}.$$

in which E represents Young's modulus for the material of the bar. What assumption have you made? (16)

11. Sketch a simple slide-valve showing cylinder ports and no more of the cylinder; show the valve in its mid-position. Show in dotted lines the position of the valve when the piston has just begun its stroke.

What do we mean by outside lap of a valve, inside lap, advance and half travel? The half travel is 3·36 inches, advance 42°. What simple diagram enables us to find the distance of the valve from its mid-stroke for any position of the main crank? Prove it correct.

Having such a diagram, we obtain the openings of the port to steam or exhaust by subtracting the outside or inside lap; explain how this occurs. (16)

12. Show that the moment of inertia of a body about any axis is equal to the moment of inertia about the parallel axis through the centre of mass, together with the moment of inertia of the whole mass collected at the centre of mass about the original axis.

The edges of an uniform rectangular parallelopiped are $2a$, $2b$, $2c$, respectively.

Find the moment of inertia of the body about a diagonal of a face whose sides are $2a$, $2b$, respectively. (16)

Parts II. and III. Third Paper.

JUNE 9TH, 1903. 10 A.M. TO 1 P.M.

Only SIX *questions to be answered.*

1. There are three collinear points in a vibrating link. The component motions of two of the points in a certain direction are simple harmonic, the amplitude and advance of each being known. Show how to find the component motion of the third point.

A Stephenson link motion with open rods has the following dimensions :—

Radius of each eccentric 2·5″, advance 18°.
Length of link 18″, effective length of slot 11·5″.
Length of each eccentric rod 55″.

Find the half-travel and advance of the valve when working at full gear. (16)

2. What is the law connecting pressure, volume, and temperature of 1 lb. of air if at 1 atmosphere and 0° C. the volume is 12·39 cubic feet? At $2\frac{1}{2}$ atmospheres and 130° C. what is its volume? It receives heat energy equivalent to 300,000 foot-pounds at constant *volume*. What are its new pressure and temperature? The specific heat of air at constant *pressure* is 0·238. (16)

3. Four masses are attached to a rotating shaft, particulars of which are given on the accompanying pictorial view, the scale for which is 1 inch to the foot for lengths parallel to *OX*, *OY*, *OZ*.

Find the magnitudes and angular positions of two masses, placed one in each transverse plane through *O* and *A*, at a radius of 1 foot, which will balance the given masses. Show the positions of the masses in the pictorial view. (16)

4. A boiler is capable of generating steam sufficient for 1,800 H.P., when the engines use 18 lbs. of steam per I.H.P. per hour, the feed temperature being 65·5° C. At working pressure, viz., 225 lbs. absolute (temp. 200°C., vol. per lb. 2·02) ; the boiler contains 2·43 tons of fresh water, and the steam space is 78 cubic feet. If the fires be in the condition for generating steam at the above rate, the stop valves closed and the feed water supply shut off, estimate how long it will be before the pressure reaches 385 lbs. absolute (temp. 226·1° C., vol. per lb. 1·21). Compare your result with the result obtained by neglecting the weight of the steam in the boiler. (16)

5. Answer only *one* of the following (*a*) or (b) :—

(*a*.) Find the algebraic formula in common use for the effective pressure in a cylinder, taking the usual hypothetical indicator diagram ; expansion law "pv^n constant." Take two cases : when $n = 1$ and when n has any other value. Take initial pressure as p_1, back pressure as p_2. (16)

(*b.*) If it be taken that 1lb. of water receives 1 unit of heat for every degree of rise of temperature, find the entropy of 1 lb. of water at any temperature. Now write out in terms of the temperature, the entropy of 1 lb. of stuff which is 10 per cent. water, 90 per cent. steam. (16)

6. Dry steam expands, in the high-pressure cylinder, from a pressure of 203 lbs. (temp. 195° C.) to a pressure of 80 lbs. (temp. 155·5° C.) absolute, the hot well discharge being 10 lbs. per minute. The jacketed service of the H.P. cylinder is 1·58 square foot, and the wall thickness is ·4". Assuming that the steam just remains dry during expansion, estimate the necessary difference in temperature between the jacket and cylinder side of the walls, having given that the flow of heat per minute per square foot per degree difference of temperature per inch thick is 5·4 Thermal units. (16)

7. In naval practice, the boiler steam is frequently wire-drawn from a pressure of 300 lbs. gauge (temp. 216·7° C.) to 250 lbs. gauge (207·8° C.) before entering the engines. If the dryness fraction of boiler steam be ·95, estimate the dryness fraction on the engine side of the reducing valve, and also the work done per lb. of stuff in the cylinder, on the Rankine cycle—the back pressure being 2 lbs. absolute (temp. 52·2° C.). Find also the percentage loss of work in the cylinder due to wire-drawing—all effects of clearance, etc., being neglected. (18)

8. Describe how a furnace is fed with coal and air. What are the conditions that must be satisfied for good combustion and for the efficient communication of heat through the metal to the water? Why is it that with forced draught less air need be supplied per pound of fuel? (16)

9. Find the quantity of feed-water that can be supplied to a boiler per lb. of steam by an injector which draws water from a feed-tank at its own level, having given that the temperature of the water in the tank is 15·5° C., in the feed delivery pipe 82·2 C., and that the steam supplied to the injector from the boiler has a pressure of 120 lbs. absolute (temp. 171·7° C.) and a dryness fraction of ·9. If the pressure of the steam at the steam orifices be 65 lbs. absolute (temp. 147·8° C.), find the velocity of the feed-water after contact with the steam jet. (18)

10. A perfect gas flows, through an orifice, from a region at pressure p_1, into a region at pressure p_2. If the flow be a diabatic show that the discharge is a maximum when

$$\frac{p_2}{p_1} = \left(\frac{2}{\gamma + 1}\right)^{\frac{\gamma}{\gamma - 1}}.$$

where γ is the ratio of the specific heats.

Experiment shows that the flow is sensibly constant for all values of p_2 less than, about, half p_1. Point out the probable defects in the theory. (16)

11. Show how to find by integration the centre of pressure of a plane area immersed in homogeneous liquid at rest under gravity.

Find the position of the centre of pressure of a circular disc radius r, its plane being inclined 30° to the vertical, and its centre being at a depth $6r$ below the surface of the liquid. (16)

12. An uniform circular cylinder, diameter 6 inches, and length 18 inches, has a specific gravity $\frac{1}{2}$; examine whether it is possible for the cylinder to float in stable equilibrium (1) with the axis vertical, (2) with the axis horizontal. (16)

Parts II. and III. Fourth Paper.

JUNE 9TH, 1903. 2 P.M. TO 5 P.M.

Only SIX *questions to be answered.*

1. Show a Meyer or other form of valve gear, by means of which a variable cut-off can be effected over a considerable range, say from admission to 0·6 of the stroke, without undue wire-drawing.

Draw a valve diagram that would be suitable for such a case, and state what information can be obtained from it. (16)

2. Feed water 25° C.; steam 10 per cent. wet; that is, there is 0·1 lb. of water to 0·9 lb. of steam at 170° C. If 25 lbs. of this wet steam enter the cylinder per hour per indicated horse-power, how much of the heat passes to the exhaust? If the stuff leaves the cylinder as saturated steam and water at 105° C., what is its wetness? Neglect radiation or other loss of heat by the cylinder. (16)

3. Atmospheric air is compressed adiabatically into a chamber of given volume to n times the atmospheric density. It is cooled down, in the chamber, to its original temperature and then expanded adiabatically in a motor (as in a torpedo) down to atmospheric pressure. Show that the ratio of the work got out of the motor to the work put into the compresser is

$$\frac{(n-1)-\gamma(n^{\frac{1}{\gamma}}-1)}{(n^{\gamma}-1)-\gamma(n-1)}$$

in which γ is the ratio of the specific heats.

4. Sketch the arrangement of the cylinders, crank shafts and balance weights of the engine in the Lanchester motor car. Show that the inertia effects of the pistons and connecting rods may be perfectly balanced in this engine. (16)

5. Poiseuille's experiments on the flow of a viscous fluid in capillary tubes show that the loss of head varies as the velocity and inversely as the square of the diameter; D'Arcy's experiments on the Paris water mains show that it approximately varies as the square of the velocity and inversely as the diameter. Explain the reason of the difference and discuss the experiments of Reynolds, which give a law of resistance for all sized tubes at all speeds of flow. (16)

6. Given the following numbers for steam, use squared paper to find dp/dt at 150° C. The latent heat of steam at 150° C. is 500·8 in pound Centigrade units; find the volume of a pound of steam at 150° C.

$\theta°$	145	150	155
Pressure in pounds per sq. foot	8698	9966	11380

Prove your formula. (16)

7. A steam engine of 6″ stroke runs at 420 revolutions per minute. The connecting rod is 12″ long, its mass 30 lbs., its centre of mass G 4½″ distant from the crank end, and its radius of gyration about G 5″. Determine the resultant orce due to the inertia of the rod when the crank is 45° from the inner dead point. (16)

8. A centrifugal pump of 4′ diameter running at 200 revolutions per minute pumps 5,000 tons of water from a dock in 45 minutes, the mean lift being 20 feet. The area through the wheel periphery is 1,200 square inches and the vane angle is 26°. Determine the efficiency of the plant. Also find the lowest speed to start pumping against the head of 20 feet, the inner radius being half the outer. (16)

(9 or 10, not both.)

9. Piston 115 sq. inches in area. At the beginning of either stroke there is a difference of pressure of 90 lbs. per sq. inch on its two sides producing total force in the direction in which the piston is about to move. The piston and its rod weigh 410 lbs. The engine makes 130 revolutions per minute; crank 1 foot. Neglecting angularity of connecting rod, that is, assuming that the piston has a simple harmonic motion, what is the actual force at the cross-head at the beginning of either stroke?

What correction must be made when the angularity of the connecting rod is not neglected? (16)

10. In the low-pressure cylinder of an inverted direct-acting steam engine, the diameter is 68″, the stroke 4′, the length of the connecting rod 8 feet, and the effective weight of the reciprocating parts 10,000 lbs. The indicated pressures, per square inch, at the beginning of the up and down strokes is 13·2 and 8·6 lbs., whilst at the ends of the down and up strokes they are 3·4 and 6·2 lbs. respectively. Find the maximum speed of the engine in order that there should be just no reversal of thrust after the commencement of the down stroke, and estimate what would then be the effective piston pressure at the beginning of the up stroke—the steam pressures being assumed independent of speed? (18)

11. A stationary boiler of the locomotive type, provided with a feed heater in the flue, gives, when tested, the following results :—

Coal per hour in lbs. - - -	125·5
Calorific value of coal per lb. -	8,170 T.U.
Temperature in smoke box - -	353° C.
,, ,, chimney bottom -	189·5° C.
,, ,, feed before entering feed heater -	64·5° C.
,, ,, feed after leaving feed heater -	109·1° C.
,, ,, boiler steam -	195·5° C.
,, ,, outside air - -	23·9° C.
Feed in lbs. per min. - - -	22·5° C.

Find (1) the quantity of air per lb. of coal; (2) the efficiency of combustion; (3) the efficiency of the heating surface including the feed heater; (4) the efficiency of the boiler, assuming dry steam to be produced; and (5) the equivalent lbs. of water evaporated from and at 100° C. per lb. of coal—the specific heat of the products of combustion being taken as ·24, and external radiation and conduction neglected. (16)

12. Investigate the equation

$$dp = \rho (X\,dx + Y\,dy + Z\,dz).$$

A rigid cylinder is closed at the ends and is filled with water; it is 2 feet in diameter and 1 foot long, and makes 2,000 revolutions per minute about its axis, which is vertical; find the whole pressure in pounds exerted on its upper end? (18)

Graphics and Practical Geometry.

JUNE 6TH, 1903. 10 A.M. TO 1 P.M.

Answer SIX *questions only.*

1. The ends of a string are secured to two walls, and a weight of 7 lbs. is hung from an intermediate point. The inclinations of the two portions of the string to the horizontal are measured and found to be 18·3° and 27·4°. Find the pulls in the two parts of the string. (15)

2. The x, y, z co-ordinates of the ends of a line AB are (2·3″, 1·3″, 0·5″), and (0·3″, 4″, 2·1″):—

   Represent the planes of reference and the line AB in pictorial projection, stating the scales employed.

   What is the length of AB? What is its inclination to the horizontal plane? (16)

3. The plan (see flyleaf) is given of a triangular prism with equilateral ends, when resting on a rectangular face; draw the elevation of the prism on xy.

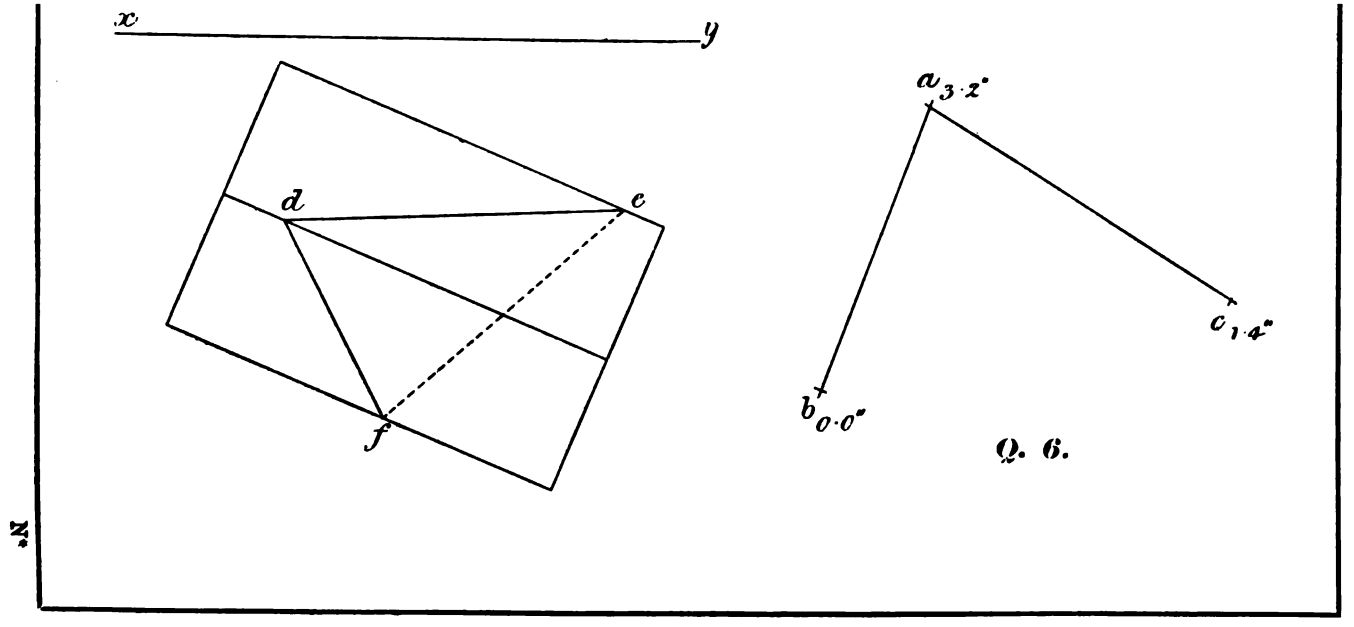
   The triangle $d\ e\ f$ is the plan of a section of the prism. Show this section in the elevation. Also find the true shape of the section. (16)

4. A mass of 10 lbs. has a velocity of $1{\cdot}3_{150}$ feet per second. It receives a blow which changes its velocity into one of $0{\cdot}8_{100}$ feet per second.

   What has been its change of velocity? What change of momentum has occurred? If the duration of the blow was 0·01 second, what was the average force of the blow? (16)

5. Draw a right-angled triangle, sides 1·8″, 2·4″ and 3·0″. This is the plan of a 45° setsquare when resting on one edge. What is the inclination of the plane of the setsquare to the horizontal? Draw any two elevations of the setsquare. (16)

6. You are given the figured plan of two intersecting lines AB, AC. Find the horizontal trace of AC. Find and measure the true angle BAC. Find and measure the inclination to the horizontal of the plane containing BAC. (16)



Q. 6.

7 A plane is inclined at 51° to the horizontal, and the lines of steepest ascent go due east; represent the plane by a scale of slope, the unit for heights being 0·1".

Show the plan of a line AB in this plane, the slope of AB being 1 vertical in 2 horizontal. (16)

8. Define the scalar product of two vectors. Let the vectors **A, B, C** denote the three circuital sides of a triangle (lengths a, b, c; opposite angles α, β, γ). By means of the vector equation

$$(\mathbf{A} + \mathbf{B})^2 = \mathbf{A}^2 + 2\,\mathbf{AB} + \mathbf{B}^2$$

deduce a formula from which an angle of the triangle can be determined when a, b, c are known. (15)

9. The roof of a house is rectangular in plan. The roof surfaces at the sides and ends are all inclined at 29° to the horizontal. Find the inclination of any one of the four sloping ridges where the surfaces intersect. What is the dihedral angle between a side and end surface of the roof? (17)

10. Find the shortest distance on the earth's surface between two places which differ in longitude by 32° and in latitude by 40°, one of the places being on the equator. Take the earth to be a sphere of 4,000 miles radius. (17)

11. A point is moving in a plane. Three successive positions, at intervals of $\frac{1}{30}$ second, are given, viz.:—

$0{\cdot}531_{0^\circ}$; $0{\cdot}395_{30^\circ}$; $0{\cdot}439_{88^\circ}$ feet.

Plot these points to a scale of 1 inch to 0·1 foot.

If B_β denote the velocity, and C_γ the acceleration of the point when in the middle position, find approximately the values of B, β, C and γ. (18)

Physics.

PART I.

JUNE 19TH, 1903. 10 A.M. TO 1 P.M.

Not more than TEN *questions are to be answered.*

1. Describe experiments made to show how the volume of a gas at constant temperature varies with the pressure, and give some account of the results obtained.

If $pv=c$, find the elasticity at constant temperature.

2. Explain the rise of water in a capillary tube which it wets, and find an expression for the surface tension in the case of a tube of circular section.

3. How may the conductivity for heat of a solid, such as slate, be determined?

A boiler is made of iron, 0·6 cm. thick, and of conductivity 0·2. A crust 0·6 cm. thick is formed inside of conductivity 0·01. If the outside of the iron is at 300°, and the inside of the crust is at 150°, what quantity of heat is conducted through each of sq. cm. per second?

4. Describe the principal phenomena of ebullition, and give some explanation of the effect of change of pressure.

5. What is meant by Resonance in sound?

Give an explanation of its production in some special case.

How may resonance be used to detect the overtones of a wire?

6. Give a general explanation of the phenomena produced when a beam of parallel white light falls normally on a diffraction grating.

If a grating has 1,000 lines to the centimetre, how far will the *D* lines (wave-length ·000060 cm.) in the first spectrum be from the central image on a screen 1 metre from the grating?

7. Describe one method of producing polarised light, and a method of showing that it is polarised. What conclusion can be drawn as to the nature of the disturbance constituting light?

8. How could you measure the Specific Inductive Capacity or Permittivity of a slab of ebonite, given a sliding condenser, a gold leaf electroscope, and a set of accumulators?

9. How may Joule's law for the heat effect be deduced, and what assumptions are made in deducing it?

If electric energy is sold at 4*d.* a unit of 1,000 Watt hours, what is the cost of heating 1 litre of water from 5° C. to 100° C.?

10. A copper disc can rotate freely on a horizontal axis with its lower part between the poles of a magnet. A current is introduced at the centre, and is taken out at the lowest point. Show that the disc will revolve, and that its speed will be proportional to the current.

11. State Kepler's Laws, and show how they demonstrate the truth of the law of gravitation throughout the solar system.

12. What is meant by the synodic period of a planet?

Given that the synodic period of Saturn is 378 days, calculate the sidereal period of the planet.

13. How does the approach or recession of a source of light affect the spectrum afforded by it? In what way has the effect been applied in investigating the constitution of the rings of Saturn?

14. Describe the method of observing solar prominences without an eclipse, and explain the principle upon which it depends.

PART I.

JUNE 19TH, 1903. 2 P.M. TO 5 P.M.

Not more than TEN *questions are to be answered.*

1. Define Mass and Weight. How would you prove that while Weight varies at different points of the Earth's surface Mass is constant?

2. Describe some method of compounding two simple harmonic motions at right angles, and explain the effects observed when the ratio of the periods differs slightly from a simple fraction such as $\frac{1}{2}$.

3 Young's Modulus for a steel wire being 2×10^{12} dynes per sq. cm. and its breaking stress 2×10^{10} dynes per sq. cm., calculate approximately the strain energy per c.c. when it is just about to break, assuming that the modulus remains the same to that point.

4. Describe a method of determining the expansion of mercury with rise of temperature.

Knowing the expansion of mercury, describe exactly how you would find the expansion of another liquid between 0° and 100°.

5. Describe the Steam Calorimeter and explain how it has been used to find the Specific Heat of a gas at constant volume.

6. The Specific Heat of air at constant volume is 0·172, and that at constant pressure is 0·238.

If the density at 0° and 760 mm. is 0·001296 and the co-efficient of expansion at constant pressure is 0·00365, determine the value of the mechanical equivalent of heat. Discuss the assumption made in this method.

7. A source of sound of low pitch is emitting its note outside a long corridor ending in a flat wall. An observer walking along the corridor hears alternations of intensity of the sound. How do you explain this, and knowing the frequency of the note how would you calculate the velocity of sound?

8. Explain what is meant by Dispersive power, and describe the construction and advantages of some form of direct vision prism.

9. Describe (1) a lens method, (2) a prism method of obtaining an erect image in a telescope.

10. Describe a form of attracted disc electrometer. If the upper disc has a diameter 5 cm., and the distance apart is 0·5 cm., calculate the P.D. when the pull on the upper disc is 800 dynes.

11. Give an account of the method of determining the Horizontal Intensity of the Magnetic Field at a point.

If you know the value of the Horizontal Intensity at one point in a laboratory where there is much iron, how can you find the value at another point in the laboratory?

12. Find an expression for the magnetic field of a solenoid, and explain how such a coil may be used for measuring the permeability of a sample of iron wire.

Practical Examination in Physics.

ELEMENTARY CLASS.

JUNE, 1903.

GENERAL REGULATIONS.

1. Each candidate will only be required to attempt four questions.

2. The time allowed for two questions is three hours.

3. Each candidate is required to write a very brief description of the method and apparatus he employs.

4. No credit will be given for results without the actual measurements on which they are based.

5. Credit will be given for accuracy and method in arithmetical calculations, and for clearness in the description of the work.

6. *No marks will be given for the numerical result of an experiment if this numerical result has not been fully worked out.*

7. Tables of logarithms and slide-rules may be used.

8. Each candidate must write his name legibly on the top right hand corner of his paper, *and use a separate sheet for each answer.*

9. *The mark or characteristic number of the specimen given must be noted in the answer.*

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1. Determine the least volume of the given solid necessary to sink the given glass float in water at the temperature of the laboratory.

2. Determine the moment of inertia of the given body.
   The moment of inertia of a cylinder of length l, radius r, and mass M, about an axis through its centre of gravity
   and at right angles to its axis is $M\left(\frac{l^2}{12}+\frac{r^2}{4}\right)$.

3. Determine Young's modulus for the given wire.

4. Determine Young's modulus for the given bar.

   For a bar $Y = \frac{p}{4BD^3} \cdot \frac{L^3}{l}$ where l is the bending at the centre produced by a load of p dynes, and B, D and L are the breadth, depth and length of the bar respectively.

5. Find a point in the given compound pendulum about which the time of swing is a minimum.

6. Determine the absolute pitch of the given fork.

7. Find the length of wire of the same material as the given wire, and of ·0914 cms. diameter, which will give a note of 400 vibrations per second when vibrating transversely under a tension of 10 kilos.

8. Find the length of the given rod which will give a note of 380 vibrations per second when vibrating transversely with one end fixed.

9. Determine the specific heat of the given solid. Specific heat of copper is 0·095.

10. Determine the specific heat of the given liquid by dropping ice into it.

    Latent heat of ice = 80.
    Specific heat of copper = 0·095.

11. Determine, by plotting a cooling curve, the melting point of the given solid.

12. Determine, by means of the optical bench, the refractive index of the glass of which the given lens is composed.

$$\mu - 1 = \frac{1}{F} \frac{r\, r_1}{r_1 - r}$$

    where F is the focal length of the lens and r is the radius of curvature of the surface nearer the object.

13. Determine the refractive index of the given liquid.

14. Find the wave length of the given spectrum line by means of a diffraction grating.

15. Find the refractive index of the given liquid by total internal reflection.

16. Determine the specific resistance of the material of which the given wire is composed.

17. Find the current in amperes required to produce a deflection of 45° in the given galvanometer when passed through the thick wire coils.

The electro-chemical equivalent of copper in C.G.S. units is ·00328.

18. Find the resistance of the given cell by measuring, with a potentiometer, the potential difference between the terminals on open and closed circuit.

19. Determine accurately the resistance of the given coil by comparing it with the given standard 1 ohm coil.

20. Determine at what distance from the centre of the given magnet, along a line drawn through its centre at right angles to the axis, the magnetic force due to the magnet is the same as it is at a point 20 cms. from the centre measured along the axis.

THIRD YEAR.

JUNE 19TH, 1903. 10 A.M. TO 1 P.M.

Not more than EIGHT *questions are to be answered.*

1. Two vessels stand side by side in an enclosure, one containing pure solvent, the other a dilute solution. In the steady state the latter stands H above the former. Show that the osmotic pressure is $g\rho H$ where ρ is the density of the solution. Show that the osmotic pressure may be defined as the pressure which must be put on to the solution to make its vapour pressure equal to that of the solvent.

2. Describe some method of measuring the expansion of a metal rod with rise of temperature. Discuss all the difficulties of the method.

3. Show that it a body is subjected to a sudden stress dS its change of temperature will be

$$d\theta = \frac{\theta e dS}{JK\rho}$$

where e is the strain per 1° rise at constant stress, K is the specific heat at constant stress, and ρ the density.

Apply the formula to determine whether a spiral steel spring will be heated or cooled on sudden expansion.

4. Give an account of the formula of Van der Waals connecting the temperature and pressure of a gas, and discuss any one modification which has been proposed.

5. How are combination tones accounted for? How have they been shown to have an existence outside the ear?

6. Describe some form of Interferometer. How do you account for the production of interference bands when the path difference is several centimetres?

7. Investigate an elementary theory of the diffraction grating and show that while the dispersion depends on the number of lines to the centimetre, the definition depends on the total width.

8. A uniaxal crystal cut with parallel surtaces perpendicular to the axis is interposed normally between a polariser and an analyser. How would you arrange a train of lenses to throw an image of the rings on to the screen? Give a drawing indicating the arrangement for the best effect.

9. Give an account of the Thermo-electric diagram.

10. Describe in detail some one method of measuring a resistance in absolute units and discuss the advantages and disadvantages of the method.

11. Show approximately how the potential difference between a reversible hydrogen electrode and an acid solution depends upon the pressure of the gas.

12. A periodic E.M.F. is applied to the terminals of a circuit consisting of a condenser and a resistance having self-induction placed in series. Find an expression for the difference in phase between the current and the applied E.M.F. What are the conditions that this phase difference shall be zero?

THIRD YEAR.

JUNE 19TH, 1903. 2 P.M. TO 5 P.M.

Not more than EIGHT *questions are to be answered.*

1. If Y is Young's Modulus, n the rigidity modulus, and x the bulk modulus of a body, show that

$$\frac{1}{Y} = \frac{1}{3n} + \frac{1}{9x}.$$

Show that Poisson's Ratio $= \frac{Y - 2n}{2n}$.

2. Investigate the theory of the steady flow of a viscous liquid through a tube of fine circular bore.

3. Define the meaning of equal temperature intervals and of the zero on the work scale.

Explain and discuss any one method of determining the temperature on the work scale corresponding to 0° C.

4. Describe how Hydrogen has been liquefied and give an account of the thermodynamics of the method.

5. Show that if u is the particle velocity in a sound wave and U is the velocity of sound, then u/U = pressure excess / elasticity.

In a train of waves in air having frequency 250 the amplitude of vibration is ·01 cm. What is the order of the maximum excess of pressure?

6. Find the velocity of transmission of a disturbance along a string stretched with constant tension.

Hence deduce the mode of vibration of a string stretched between two points.

7. Give a general account of some theory of the dispersion of light.

8. Show that the rotation of the plane of polarisation of light by an active medium may be represented by the resolution of the plane disturbance into two opposite circular disturbances travelling at different rates.

Describe and explain the action of a half-shadow polarimeter.

9. Show that a small magnet in a field tends to set in the direction of greatest slope of potential but tends to travel bodily in the direction of greatest slope of intensity.

10. Investigate the law of refraction of tubes of magnetic induction passing from air into a medium with permeability μ.

How do you account for the fact that iron filings cluster against magnetised iron always sensibly at right angles to the surface.

11. How has the ratio of the Electromagnetic to the Electrostatic Unit of electricity been determined?

12. Investigate an expression for the E.M.F. of a voltaic cell, taking into account reversible heat changes.

Practical Physics.

THIRD YEAR.

JUNE, 1903. 10 A.M. to 1 P.M. and 2 P.M. to 5 P.M.

1. Assuming that the 20 gram weight and the fractions of a gram supplied are correct, find the true values of the two given 10 gram weights.

2. Find the vapour density of the given liquid at 100° C.

3. Find the specific heat of the given solid.

4. Find the refractive index for sodium light of the given liquid by the method of total reflection.

5. Determine approximately the nature of the light emergent from the given crystalline plate when plane polarised sodium light is incident normally and the plane of polarisation is inclined at 45° to the singular directions.

6. A magnet is placed so that its axis passes perpendicularly through the centre of a plane surface. Plot a curve showing the relation between the induction through the surface due to the magnet and the distance of its centre from the surface.

7. Find the ratio of the resistances of the two given narrow tubes when filled with the same electrolyte.

8. Find how the capacity per unit surface of an electrode of the given material depends upon the polarising electromotive force.

Practical Physics.

SECOND YEAR.

JUNE, 1903. 2 P.M. TO 4 P.M.

1. Find the ratio of the moments of the two given magnets.

2. Find the specific heat of the given liquid by the method of cooling.

3. Find, with the apparatus supplied, the ratio of the currents required to keep the given motor rotating at two different speeds of which one is double the other.

CHEMISTRY.—PARTS II & III.

Organic Chemistry (Elementary Course).

JUNE 24TH, 1903. 10 A.M. TO 1 P.M.

Not more than EIGHT *questions are to be attempted.*

Formulæ and equations should be given whenever necessary for explanation.

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1. What substances are obtainable from ethyl alcohol by the action of sulphuric acid? Specify the conditions which favour the production of each.

2. How would you distinguish experimentally between—

(*a*) an aldehyde and a ketone,
(*b*) an alcohol and a phenol,
(*c*) an amine and an amide,
(*d*) an ester and an anhydride?

3. How is acetylene prepared (*a*) in large quantities, (*b*) in the purified state? Describe its physical and chemical properties.

4. State what occurs when a carboxylic acid is (*a*) distilled with lime, (*b*) treated with phosphorus pentachloride, (*c*) heated with a mixture of ethyl alcohol and sulphuric acid. How can the product in the last two cases be made to yield the amide?

5. Describe briefly the operations by which diazoaminobenzene may be obtained from benzene.

6. How may benzaldehyde be converted into (*a*) benzyl alcohol, (*b*) benzal chloride, (*c*) cinnamic acid, (*d*) mandelic acid?

7. Describe the preparation of any *two* of the following substances:—Salicylic acid, anthraquinone, β-naphthylamine, phthalic acid, iodoform, anhydrous glucose.

8. What do you understand by isomerism? Illustrate your answer by reference to the isomerism of (*a*) ethylene and ethylidene dichlorides, (*b*) racemic and ordinary tartaric acids, and indicate the evidence on which your statements are based.

9. Compare acetonitrile and methyl carbamine with respect to their methods of formation and properties and, from a consideration of these, deduce the constitutional formula of each compound.

10. Explain the reasons for identifying urea as carbamide. What substances are formed when urea is submitted to the action of (*a*) heat, (*b*) sodium hypochlorite, (*c*) nitrous acid ?

11. Distinguish between primary, secondary, and tertiary amines. Describe the reactions by which amines of the three types can be distinguished from one another.

12. What are the reasons which have led to the adoption of a cyclic or ring formula for benzene ?

Physical Chemistry.

FEBRUARY 7TH, 1903. 10 A.M. TO 1 P.M.

You are permitted to attempt EIGHT *questions only.*

1. " The greater the molecular weight of a compound, the higher is its boiling point." Criticise this statement.

2. The depression of the freezing point of benzene produced by a certain solute is found to be abnormally small. What explanations might be given of this ?

3. At 49°·7 the vapour density of nitrogen peroxide under a pressure of 26·8 mm. is 1·663 (relatively to air). Calculate what the vapour density should be at the same temperature under a pressure of 497·8 mm.

4. What is meant by " transition temperature " ? Indicate two methods of determining transition temperatures, and give examples by way of illustration.

5. The specific volume of a substance at its critical temperature is found to be V_k ; calculation, with the help of van der Waals' equation, leads to the value v_k. How far do these two values agree, and what relation do they bear to v, the critical specific volume, calculated on the assumption that the simple gas laws hold down to the critical temperature and at the critical pressure ?

6. What experimental evidence can be brought forward in support of the view that osmotic phenomena are due to the selective solubility of the semi-permeable membrane ?

7. For monobromacetic acid at 25° the values (λ) of the equivalent conductivity at the dilutions v are as follows :—

v	λ
32	68·7
128	122·3

Calculate (1) the degree of dissociation in each of these solutions ; (2) the dissociation constant of monobromacetic acid; having given that at 25°

λ_∞ for $CH_2Br \cdot COONa = 90{\cdot}5$
$\mu_H = 320{\cdot}5$
$\mu_{Na} = 49.$

8. Give an outline of the work that has been done on the rate of saponification of esters by bases.

9. Explain the law of "the rectilinear diameter," and point out any result of practical importance that may be arrived at by the application of the law.

10. What do you understand by "hydrolytic dissociation"? Quote a few common examples. By what methods may the extent of hydrolytic dissociation be determined in a given case?

11. State and criticise the "law" of Dulong and Petit. Find the atomic weight of an element, the mean between 0° and 100° L. H. of which is ·103, and the chloride of which contains 54·57 per cent of chlorine.

12. By what methods can it be shown that the formation of hydrazin iodide is attended by the absorption of heat energy?

Organic Chemistry (Advanced Course).

Parts II. and III.

JUNE 24TH, 1903. 10 A.M. TO 1 P.M.

Not more than EIGHT *questions are to be attempted.*

Formulæ and equations should be given whenever necessary for explanation.

1. How do diacetyl, acetylacetone, and acetonylacetone (*a*) differ from one another, (*b*) resemble one another? Give systematic names for these substances.

2. What is guanidine? How is it prepared, and how may it be converted into (*a*) semicarbazide, (*b*) hydrazine, (*c*) hydrazoic acid?

3. What is purine? Discuss its relationship with uric acid, and state how it may be obtained from that substance.

4. A sugar having the empirical formula $C_{12}H_{22}O_{11}$ yields an octacetyl derivative and an osazone; it ferments readily with brewers' yeast, and when hydrolysed with dilute acids gives rise to *d*-glucose only. Identify the sugar, stating which of the foregoing properties distinguishes it from the isomerides.

5. What is understood by "steric hindrance"? Describe the abnormal behaviour of 2:4:6-trimethylbenzoic acid, acetylmesitylene, and 1-amino-2:6-dimethylbenzene which has been ascribed to this phenomenon.

6. How are indigo-blue and indigo-white related to indole? Describe the operations by which synthetical indigo is now prepared on a large scale.

7. Specify the elements other than carbon which have been shown to cause optical activity in their asymmetric derivatives, and describe the experiments by which a racemic compound of any one of them has been resolved into optically active components.

8. Indicate the steps by which *one* of the following substances has been obtained synthetically: *d*-fructose, piperine, ionone.

9. Give an account of Fenton's researches on the use of hydrogen peroxide as an oxidising agent in the presence of ferrous sulphate, and explain how, by means of this method, glycolic aldehyde may be obtained from tartaric acid.

10. How are the nitroparaffins prepared, and in what respects do they differ from nitrobenzene or nitronaphthalene? Discuss the reasons for assigning tautomeric formulæ to the nitroparaffins and their alkali derivatives.

11. Give an account of the arguments adduced in favour of the view that the benzene molecule contains doubly-linked carbon atoms.

12. What are the characteristic reactions of unsaturated acids? Two forms of crotonic acid have been described: how are they distinguished, and how do you account for their isomerism?

Practical Chemistry.

JUNE 18TH, 1903. 10 A.M. TO 5 P.M.

FIRST DAY.

(*A.*) The given aqueous solution contains a phosphate. Determine the amount of each of the radicles present in one litre of the solution.

The phosphoric acid determination may be completed to-morrow.

(*B.*) Analyse qualitatively the given mixture.

JUNE 19TH, 1903. 10 A.M. TO 5 P.M.

SECOND DAY.

The given aqueous solution contains an organic substance. Identify the products obtained by warming it with sodium hydroxide solution, and leave specimens of any derivatives you are able to prepare from it in a pure state.

The decomposition with alkali being quantitative, ascertain the amount of sodium hydroxide required to decompose the quantity of substance contained in 50 c.c. of the given solution, and from this result calculate the amount of the substance dissolved in one litre.

Biology.—Part III.

Final Botany.—Paper I.

JUNE 18TH, 1903. 10 A.M. TO 1 P.M.

1. Investigate the anatomy of A. Illustrate your preparations by means of lettered sketches.

2. Describe and point out the features of interest in slides B and C (silicified fossil).

Part III.

Final Botany.—Paper II.

JUNE 18TH, 1903. 2 P.M. TO 5 P.M.

1. Refer the specimens D and E to their respective natural orders, giving your reasons.

2. Make preparations to demonstrate the structure of F. Illustrate your preparations by sketches.

3. Describe, and as far as possible identify, G and H (slides).

4. Comment on any points of morphological interest observed in J and K.

A *viva voce* will be held during the afternoon.

Part III.

Final Botany.—Paper III.

JUNE 19TH, 1903. 10 A.M. TO 1 P.M.

Not more than FIVE *questions are to be attempted.*

1. Give a short account of the recent and extinct genera of the Lycopodineæ, and discuss the affinities of the group as a whole.

2. Discuss the question as to the origin of the perianth in the archichlamydeæ.

3. Describe the chief structural adaptations in the testa and pericarp that facilitate the dispersal of the seed by means of wind or by water-currents.

4. Write a comparative account of the morphology of the fructification of the Ascomycetes.

5. Give a general account of our knowledge of the Cordaiteæ, and discuss their relations to existing gymnosperms.

6. Discuss the nature and value of the evidence in favour of the permanence of the chromosomes.

7. Cite instances of alleged parthenogenesis in flowering plants, and criticise the evidence on which they rest.

8. Give examples of convergence of habitus on the part of diverse groups of plants in response to uniform conditions of specialised environment, discussing the matter from a general standpoint.

Part III.

Final Botany.—Paper IV.

JUNE 19TH, 1903. 2 TO 5 P.M.

Not more than FIVE *questions are to be attempted.*

1. What is meant by "Respiratory Quotient"? In what ways may it be taken as an index of metabolic processes?

2. Discuss the significance of irritability. How do considerations as to the conditions essential to its manifestation serve to elucidate the nature of the phenomena?

3. Give some account of the vegetation met with in *one* of the following typical districts:—

(*a.*) Margin of a lake.
(*b.*) Sandy coast with dunes.
(*c.*) Muddy tropical estuary.

Explain the ecological relations of the vegetation in the region you select.

4. Enumerate, and indicate the relationship between, the principal marchantioid genera of Hepaticæ. Trace the evolution of the archegoniophore in the group.

5. What is meant by the term Mesarch? Cite instances of plants in which mesarch structure occurs, and discuss its significance in the evolution of the vascular system.

6. Give an organographic account of the vegetative and reproductive organs in the Phæophyceæ.

7. Draw the floral diagram of *one* of the following:—

Veronica, Plantago, or Butomus.

Explain the significance of the special peculiarities of the one you select.

8. What anatomical features are associated with the aeration of tissues? Briefly describe the mode of origin and the structure of the principal types.

Geology.—Part I.

JUNE 15TH, 1903. 10 A.M. TO 1 P.M.

You are not permitted to answer more than EIGHT *questions. All the questions receive the same proportion of marks.*

1. Explain the actions by which rocks forming precipices on high mountains are rapidly disintegrated. Why is it dangerous for travellers to pass such precipices after the sun has been up for some time?

2. In what way is silica made to pass into solution in natural waters? What are the chief organisms which separate silica from such waters to form the substance of rocks?

3. Enumerate the chief geological formations in England from which calcium phosphate has been obtained for commercial purposes and explain the presence of the nodules in any one of these.

4. What is a septarian stone? Give a history of one from any deposit in which septaria are common; especially of the various stages in its formation.

5. Explain the difference between a delta and an estuary, and state the causes which determine the formation of each.

6. Describe the forms of the chief varieties of volcanic cones, and show how these forms are dependent on the nature of the materials of which they are composed.

7. By what criteria would you distinguish an intrusive sheet ("sill") from an ordinary lava flow, when intercalated with stratified rocks?

8. Explain, by the aid of diagrams, the chief varieties of faults and of combinations of faults with which you are acquainted.

9. Describe the mineral and structural changes which occur in the vicinity of a mass of granite which has been intruded into a clay slate.

10. State what you kn[illegible] oncerning the nature, modes of preservation an[illegible] these fossils [illegible] geologist?

11. What are the peculiarities of the coalfields of South Wales, South Staffordshire, Northumberland, and the Central Valley of Scotland respectively, and what light do these throw on the physical geography of the period?

12. Enumerate the several areas in Great Britain where rocks of undoubted Cambrian age occur. Give a general account of the lithological characters of the rocks and state what materials of economic value are obtained from them.

JUNE 15TH, 1903. 2 P.M. TO 5 P.M.

You are not permitted to answer more than EIGHT *questions,* FIVE *of which must be selected from Series I. Students taking Mining or Metallurgy for their final subject must select their remaining three questions from Series II. All other Students must select their remaining three questions from Series III.*

Write your answers to the questions from each series on separate papers.

SERIES I.

1. Draw two crystals of minerals of the Zircon Type, showing the position of the axes, and indicating the difference between prisms and pyramids of the First and Second Order respectively.

2. Draw a crystal of Leucite in proper position with its axes. State the grounds on which the cubic nature of Leucite has been regarded as doubtful.

3. State what you know concerning the crystalline form of the micas. How do Muscovite and Biotite differ in their optical characters?

4. Describe the relations which exist between the crystals of Calcite, Dolomite, and Chalybite, and state the chemical composition of these three minerals.

5. How would you recognise and distinguish under the microscope thin slices of biotite and chlorite, of tourmaline and similarly coloured hornblende and of nosean and elaeolite?

6. State what you know concerning the chemical composition of garnets. In what rocks do garnets occur as a? How may garnets be recognised the microscope?

7. Give some account of the chief varieties of nepheline-bearing rocks, indicating their usual mode of occurrence.

8. Describe the mineral serpentine, and show that varieties of this mineral have been formed from more than one mineral.

Series II.

9. Enumerate the principal ores of Manganese, giving for each mineral its chemical composition and more striking physical properties. What is the usual mode of occurrence of Manganese deposits?

10. Mention the different circumstances under which Gold is found, and explain, as far as possible, its presence in each case.

11. Give a detailed account of the mineral Galena, its chemical composition, crystalline form and physical properties. State also its principal modes of occurrence, associated minerals, and products of alteration.

12. State the means by which you would distinguish between:—

Cuprite and Cinnabar,
Antimonite and Bismuthine,
Copper Pyrites and Tin Pyrites,
Aragonite and Witherite,
Erubescite and Copper Glance,
Mispickel and Smaltite.

Series III.

13. State what you know concerning the species of *Inoceramus* which occur in different members of the Cretaceous Series. What is the zoological position of the genus *Inoceramus*, and why is the shell, when fossil, often represented by fragments only?

14. What is the range in time of the Trilobites? Name four important genera of Trilobites from different formations, stating the formation in which each is found.

15. In what British formation does *Nummulites laevigata* occur? What foreign rocks contain great numbers of Nummulites? What do you know concerning the zoological position of the Nummulites?

16. Draw a sketch section from N[illegible] the Wealden area.

Practical Examination in Part I.

JUNE 16TH, 1903. 10 A.M. TO 1 P.M.

Write your notes about each specimen against the corresponding letter on the paper given to you.

You are requested to examine each specimen as soon as it is given to you, in no case to retain it more than 10 minutes, and to give it up to those in charge of the Examination when you have done with it.

You must not, on any ground, leave your place while the Examination is in progress.

For all Students.

1. Make a blowpipe examination of the specimens *A*, *B* *C*, respectively, and arrange your results in a tabular form. State your conclusions as to the chemical composition of each of these substances, and identify, if you are able, the particular mineral species which each represents.

2. Examine the specimens *D*, *E*, *F*: give the name of each, and note any peculiarities which it presents. State the chemical composition and crystalline form of each mineral.

3. Examine and make sketches of the crystalline bodies *G*, *H*, and the models *I*, *J*, stating the conclusions you arrive at regarding each of them, especially remarking upon any peculiarities it may present. (The mineral specimens must not be scratched or injured.)

For Students who are going out in the Mining and Metallurgical Divisions.

4. Identify the minerals *K*, *L*, *M*, *N*, confirming your results, where necessary, by blowpipe tests.

5. State what you know about the specimens *O*, *P*.

For Students who are going out in other Divisions.

6. Give an account of the minerals *S* and *T*, their [redacted]mical composition, crystalline form, physical properties, [redacted]e of occurrence.

[redacted] the fossils marked *U*, *V*, *W*, stating the class [redacted]hich each belongs, its mode of mineraliza[redacted]ation from which it comes.

JUNE 16TH, 1903. 2 P.M. TO 5 P.M.

Write your notes about each specimen against the corresponding letter on the paper given to you.

You are requested to examine each specimen as soon as it is given to you, in no case to retain it more than 10 minutes, and to give it up to those in charge of the Examination when you have done with it.

You must not, on any ground, leave your place while the Examination is in progress.

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1. Examine the six rocks *a*, *b*, *c*, *d*, *e*, *f*, stating the minerals which each contains and the name you would give to it. Note any peculiarities you may notice in the specimen.

2. Study the slides *g*, *h*, *i*, *j*, with the microscope; make drawings of them and state your conclusions concerning them.

3. Draw a section, showing beds of shale and coal broken up by a trough fault, and covered unconformably by horizontal beds of conglomerate.

4. Name the fossils *k*, *l*, *m*, *n*, stating the class of organism to which each belongs and the formation from which it comes.

(*Question 4 is* NOT *to be taken by Students going out in Mining and Metallurgy.*)

5. State what you know about the specimens *o*, *p*, *q*, *r*.

(*Question 5 is to be taken* ONLY *by Students going out in Mining and Metallurgy.*)

Metallurgy.

Theoretical Assaying.

JUNE 24TH, 1903. 10 A.M. TO 1 P.M.

The Student is expected to give, whenever possible, the chemical reactions which take place in the processes he describes.

Not more than SIX *questions are to be answered.*

The value attached to each question is the same.

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1. How would you sample the following consignments of ores?

(*a*) A cargo of iron ore.
(*b*) 10 tons of rich nickel speiss.
(*c*) 10 tons of Boleo copper bar.

2. Give details for the determination of the two following metals by electrolytic methods:—

(*a*) Copper.
(*b*) Nickel.

3. How would you determine the lead, lime, and silica in a sample of lead slag?

4. By what methods would you estimate sulphur, manganese, and arsenic in a steel rail?

5. How would you determine the amount of gold in a sample of metallic tin?

6. Describe the method you would employ for the determination of antimony and tin in a type metal.

7. How would you determine the amount of Mercury being lost in the tailings from an Amalgamation Plant?

8. Draw up a scheme for the daily work in a Laboratory of a Lead Smelting Works, where silver is extracted from lead by the Parkes' Process.

Metallurgy.

JUNE 18TH, 1903.

Morning Paper. 10 A.M. to 1 P.M.

The Student is expected to give, whenever possible, the chemical reactions which take place in the processes he describes.

Not more than SIX *questions may be answered, of which No.* 8 *must be one.*

The number of marks allotted to each question is given.

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1. Describe the Mond Gas Producer with ammonia recovery plant, pointing out the essential differences between this and an ordinary Water-bottom Gas Producer. Give an approximate analysis of Mond gas and ordinary producer gas, and explain why the composition is different. (16 marks.)

2. Give an approximate analysis of refractory materials you would select for (1) the roof of an open hearth steel furnace; (2) the lining of the hearth of a basic Siemens furnace; (3) the bottom of a copper refining furnace; (4) the lining of an acid Bessemer Converter; (5) the well and boshes of a Blast Furnace smelting iron ores; (6) the lining of a "test" for the cupellation of argentiferous lead. (16 marks.)

3. Describe, with the aid of a sketch, a modern Blast Furnace designed on American lines at some works known to you; giving particulars of the latest arrangements for charging the materials. (16 marks.)

4. Compare a modern Ford and Moncur hot blast stov with the ordinary Whitwell or Cowper stoves, pointing ou what are the special advantages claimed. (16 marks.)

5. Pig irons of the following composition are submitt to you. State which, if any, you would select (1) for A Bessemer; (2) for Basic Bessemer; (3) for Basic Siem (4) for the production of puddled iron. Give your rea briefly in each case.

(1) (3) (2) (4) (5) (6)

6. Describe a modern Tilting Open Hearth furnace suitable for the Talbot Continuous Process. (16 marks.)

7. What are the special properties of Nickel, Chrome and Manganese steels? (16 marks.)

8. Name and briefly describe the specimens. (16 marks.)

JUNE 18TH, 1903.

Afternoon Paper. 2 P.M. TO 5 P.M.

The Student is expected to give, whenever possible, the chemical reactions which take place in the processes he describes.

The number of marks allotted to each question is given.

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9. Indicate by sketches the working drawings you would prepare for the building of a large reverberatory furnace for matte smelting.

Give the chief dimensions, and specify the materials you would employ for its various parts. (16 marks.)

10. Describe in detail the production of, and the Bessemerizing of, Copper matte, and the refining of the crude copper obtained. (16 marks.)

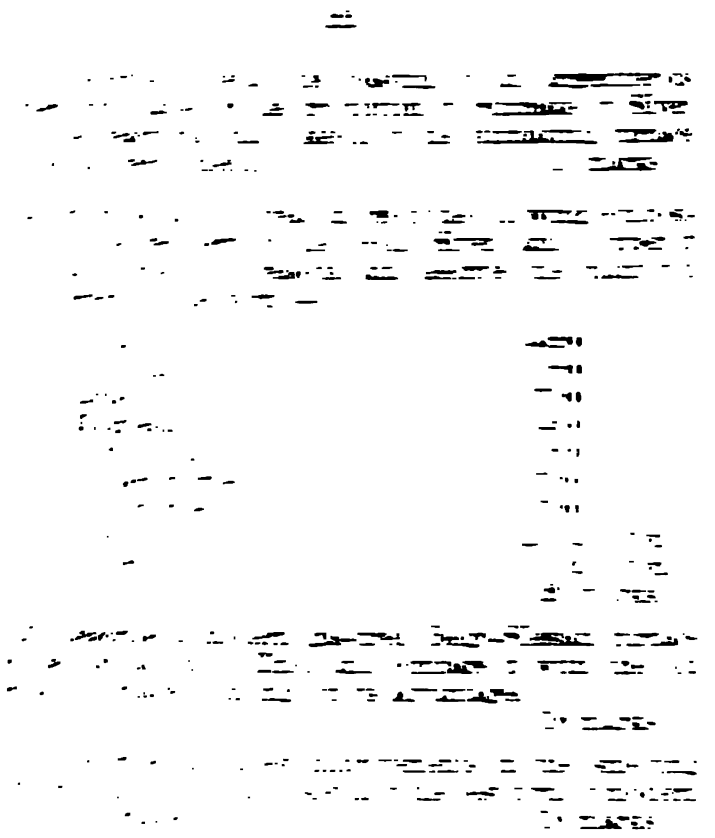
11. What is the general effect of Bismuth, Lead, Antimony, Arsenic, and Phosphorus, on the mechanical and general working properties of Copper? To what extent may they be present in copper required for tube plates of a locomotive, and in copper for the manufacture of brass for locomotive tubes? (16 marks.)

12. In smelting lead ores what are the conditions which would determine the selection of a reverberatory or of a shaft furnace?

How would you treat two ores of the following composition:—

	(1)	(2)
Galena - - -	40%	40%
Iron Pyrites - - -	18	10
Zinc blende - - -	8	4
Quartz - - - -	34	31
Copper Pyrites - -	—	10
Antimony Sulphide -	—	3
Mispickel - - -	—	2

(16 marks.)



[illegible] — [illegible]

[illegible]

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. Determine [illegible] in dolomite.
7. Determine coal in ore volumetrically.
8. Determine calcium in dolomite.

9. Determine gold in telluride ore.
10. Determine arsenic in copper precipitate.
11. Determine copper in arsenical copper precipitate.
12. Determine gold in a cyanide solution.
13. Determine silica in a refractory slag.
14. Determine potassium cyanide in a cyanide solution.
15. Determine gold, silver and copper in a triple alloy.
16. Determine lime in a refractory slag.
17. Determine silver in a complex copper ore.
18. Determine sulphur in steel.
19. Determine silver in a silver coin.
20. Determine nickel in a nickel steel.

Mining.

19TH JUNE 1903. 10 A.M. TO 1 P.M.

(*a*) *Answer the questions as far as possible in their numerical order.*

(*b*) *It is desirable that the answers should be illustrated by sketches.*

(*c*) *Neatness in answering the questions and in making the sketches is imperative.*

(*d*) *Not more than* SIX *questions to be answered.*

---

1. What are the principal sources of supply of zinc ores in Europe? Describe the minerals and their mode of occurrence characteristic of any particular locality.

2. Describe in detail the nature of the mineral occurrences in the Merionethshire gold mining district.

3. How would you ascertain the probable value of an alluvial flat containing a deposit of tin-bearing or gold-bearing gravel?

4. Describe some method of putting down a deep bore-hole rapidly, noticing modifications required when a record of the ground passed through is to be kept.

5. Describe, with sketches, a rock-drill for sinking purposes driven by compressed air, and the method of mounting it.

6. Notice briefly the leading types of construction of coal-cutting machines, and describe one form in detail.

7. A shaft is tubbed with cast-iron in rings, 5 feet high, with an intermediate stiffening rib and internal flanges each 2 inches square in section. The clear diameter inside the flanges is 13½ feet. The top ring is 1⅝ inches and the bottom one 3 inches thick. Give the respective weights of these rings. Describe how such a lining is made water-tight and secure.

8. Under what conditions can the steam navvy be applied in working mineral deposits?

9. Describe any two "permitted explosives" and explain the manner in which explosives are selected for this class.

19TH JUNE 1903. 2 P.M. TO 5 P.M.

(*a*) *Answer the questions as far as possible in their numerical order.*

(*b*) *It is desirable that the answers should be illustrated by sketches.*

(*c*) *Neatness in answering the questions and in making the sketches is imperative.*

(*d*) *Not more than* SIX *questions to be answered.*

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10. Sketch and describe a district of longwall workings in a thin seam, showing the arrangements of the ventilation and haulage roads.

11. Describe a Festiniog slate mine, giving some account of the deposits from a geological point of view, and the methods adopted in working them, hoisting slate and rubbish, and dressing the slate.

12. Name the purposes to which "conveyors" are applied at mines, and describe any "conveyors" with which you are acquainted.

13. What arrangements have been employed for caging and landing tubs from cages with several decks without moving the main winding engine?

14. Notice the general arrangements required in working a heavy lift underground pumping engine by electric power.

15. Describe the construction of a stamp battery of large output, noticing specially the construction of the battery box and discharge screen.

16. Describe the order of operations in dressing tin-stuff high in wolfram when magnetic separation is adopted as an accessory.

17. Describe the manner of cleaning, filling, lighting, locking, re-lighting, testing, storing, and distributing safety lamps.

18. In what way are mineral workings classified in this country by legislature? Explain the principal provisions of the Acts of Parliament governing the working of any one class of mines.

Mine-Surveying.

18TH JUNE, 1903.

MORNING PAPER.—10 A.M. TO 1 P.M.

1. From a traverse on the surface between two vertical shafts the true bearing from a plumb line *X* in No. 1 shaft to a plumb line *Y* in No. 2 shaft was determined to be 56° 13′. Underground another traverse was run from plumb line to plumb line with the following results :—

Distance (Feet).			Horizontal angle.		
XA	-	14·01	*XAB*	-	181° 35′ 45″
AB	-	60·13	*ABC*	-	94° 01′ 10″
BC	-	183·42	*BCD*	-	101° 30′ 20″
CD	-	33·59	*CDY*	-	170° 15′ 20″
DY	-	38·45			

What is the length of the connecting base between the two shafts, and the bearing of line *XA* ?

2. In what manner may the latitude of a place be determined from the sun or a star ?

3. Describe the construction of a five-inch transit theodolite suitable for mining work, illustrating your description by a section through the instrument, without the telescope.

4. In pointing downwards with a theodolite telescope, what devices have been suggested to overcome the difficulty caused when the angle is so great that the line of sight cuts the plate of the instrument ?

5. A mine reservoir is to be sounded to ascertain (1) its water contents, and (2) the depth of silted mud. Describe the appliances used and the mode of fixing positions by the help of two theodolites.

AFTERNOON PAPER.—2 P.M. TO 5 P.M.

6. A portion of a mining royalty was surveyed by running a line 1012 links in length through it from end to end. From the chain, offsets were taken to the right at 0, 100 200, 350, 500, 645, 786, 892 and 1012 links, the lengths of the offsets being respectively 0, 52, 84, 63, 45, 95, 80, 53 and 0 links. What was the area included between the chain-line and the boundary ?

7. A triangular enclosure was measured with a chain that was afterwards found to be one link too long. The sides, as measured, were 6 chains, 4 chains, and 3 chains in length respectively. What was the resulting area and what was the true area?

8. In what manner should a survey of a mine concession in a mountainous region be conducted for the purpose of obtaining information for the production of a map showing the conformation of the surface?

9. Describe the method of levelling along an inclined drift, giving sketches of the appliances used.

10. How would you proceed to measure accurately the depth of a vertical shaft?

BOARD OF EDUCATION.

PROSPECTUS

OF THE

ROYAL COLLEGE OF ART,

LONDON.

(For Session 1903—1904.)

PROSPECTUS

OF THE

ROYAL COLLEGE OF ART, LONDON

(Formerly called the National Art Training School).

Objects of College.

1. The Royal College of Art is established for the purpose of training Art Masters and Mistresses for the United Kingdom, and for the instruction of students in Drawing, Painting, Modelling, and Designing, for Architecture, Manufactures, and Decoration. Whilst the Royal College of Art is primarily intended for the instruction of teachers and students selected by competition in the Art Examinations of the Board of Education, other students are admitted so far as there may be accommodation for them, on the payment of fees.

Associateship.

2. The full Associateship is granted to students who have qualified in the four Schools of the Upper Division. See § 10.

The Schools Associateship is granted to students who have qualified in the School selected by them of the Upper Division. See § 11.

Certificates of merit will be awarded to students, as defined in § 45.

COURSE OF INSTRUCTION.

Outline of instruction given.

3. The instruction in the College is arranged with the view of students passing through a course of instruction either in all the four Schools of Architecture; Ornament and Design; Decorative Painting; and Sculpture and Modelling; or in one or more of the Schools only (see syllabuses of courses of instruction, p. 247 *et sqq.*).

Organisation of College.

4. The College is divided into an Upper and Lower Division, and candidates upon their admission to the College are placed in one or other according to their proficiency. The students come under two categories:—

(*a*) Those who are passing through the course for training Teachers, with the view of obtaining the Full Associateship.

4. (*b*) Those who are specialising in one or other of th four Schools of the College, with the view o obtaining the Schools Associateship.

These courses are arranged for the holders of Studentships in Training, National Scholarships, Royal Exhibitions and Free Studentships, the regulations affecting whom are given at p. 236 *et sqq*. Fee-paying students will be required to follow one or other of the above courses.

There is no age limit for candidates desiring to enter the College.

CONDITIONS OF ADMISSION AND FEES.

Free Admission.

5. Free admission is given to holders of Studentships in Training, National Scholarships, Royal Exhibitions, and Free Studentships, all of whom are exempt from the admission tests.

The period for which free admission may be continued will in each case depend upon the conduct of the student and upon his progress, which must be satisfactory to the Council. In no case can free admission exceed a total length of five years.

Fee-paying Students.

6. Other students are admitted to either of the courses (see § 3) upon payment of fees of £12 10s.† per term, or when students join at half term £6 5s. for the remainder of the term. In all cases fees must be paid in advance to the Registrar of the College.

The number of fee-paying students may not exceed 150 at any one time; and the total number of free and fee-paying students per term in the College is limited to 350.

7. Fee-paying students, highly qualified persons specially recommended by the Council or Principal of the College, for free admission, holders of County Council Scholarships, holders of Local Scholarships, and holders of Local Exhibitions, are required to comply with the conditions of §§ 8 or 9 before admission is granted.

7*a*. Local Scholars and County Council Scholars are not entitled to free admission unless specially recommended by the Council or Principal of the College.

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† Students who are in the College and have paid fees on the old scale for a less period than four years will be allowed to continue at the same rate until they have completed a period of four years.

Cheques and Post Office Orders should be made payable to the "Board of Education, South Kensington" or Order, crossed "Account of Payees— not negotiable."

ENTRANCE TESTS AND EXAMINATIONS FOR FULL ASSOCIATESHIP COURSE.

Entrance Test for Full Associateship.

8. Candidates for admission under § 7, except Scholars and Exhibitioners, who desire to enter for the course of instruction for the Full Associateship, must submit, a fortnight before the end of a term or half term, a folio of drawings as mentioned below:—

Architecture.—A careful drawing of a building, or some portion of an ancient or modern building of artistic interest.

Sculpture.—Two studies of heads carefully drawn from life with the point.

Painting.—A drawing in charcoal of an antique figure; the broad masses of light and shade only to be indicated.

An anatomical drawing (bones and muscles) of the same figure.

Ornament and Design.—Three very careful drawings of flowers and foliage, one in pencil, one in water-colour, one in pen and ink, all from the same subject.

A sheet of lettering done from good Roman capitals. The selection of a good plain type is essential.

If these drawings are approved, candidates must sit for test examinations in the four subjects, of which they must pass in three. Such test examinations will be held at the commencement of each term and half term.

The following are the subjects for the test:—

Architecture.—A drawing of a small architectural object in the Victoria and Albert Museum selected for the purpose.

Time allowed: 12 hours.

Modelling.—A model in clay of the mouth of Michael Angelo's David.

Time allowed: 6 hours.

Painting.—A drawing in charcoal from life of the head, hand, and foot, the light and shade being slightly indicated.

Time allowed: 9 hours.

Ornament and Design.—A drawing from memory of a piece of foliage such as that of the oak, ash or lime.

Lettering by hand of a given sentence, *or* a simple problem in designing, to fill a given space.

Time allowed: 9 hours.

ENTRANCE TESTS AND EXAMINATIONS FOR SCHOOLS' ASSOCIATESHIP COURSE.

9. Candidates indicated in § 7, and desiring to enter for the course of instruction for the Schools Associateship (*i.e.* to specialise in one or more of the four Schools) must state the School to which he desires to be admitted. His application with the required works must be submitted a fortnight before the end of each term or half term.

For the School of Architecture.

Entrance Test for School of Architecture.

The works to be submitted by a candidate are:—

(1.) A measured study in pencil, upon an imperial sheet, of some portion of an ancient building, to the scale of not less than ½ inch to one foot; also a drawing of mouldings, full size, and of some ornament.

(2.) A perspective sketch of the same subject.

The examination or test of the candidate at the College consists of making a drawing, to be plotted on the spot, from measurement, and executed in six days, of some architectural feature in the Victoria and Albert Museum selected for the purpose.

Time allowed: 6 days.

For the School of Ornament and Design.

Entrance Test for School of Ornament and Design.

The works to be submitted by a candidate are:—

(1.) Six drawings from nature or architecture, of which at least two must be very careful pencil drawings of flowers and foliage.

(2.) A sheet of lettering done from good Roman capitals.

The examination or test of the candidate at the College consists of:—

(1.) Drawing from a cast in pencil.

(2.) Lettering by hand of a given sentence.

(3.) Drawing from memory some piece of common foliage (*e.g.*, of the oak, ash, or lime).

(4.) A simple problem in design.

Time allowed: 3 days.

9—*cont.*

For the School of Decorative Painting.

Entrance Test for School of Decorative Painting.

The works to be submitted by a candidate are :—

(1.) A drawing in charcoal of an antique figure, broad masses of shadow only to be indicated.

(2.) An anatomical study in charcoal of the same figure (bones and muscles). The figure is to be about one-third life dimensions.

(3.) A life-size drawing in charcoal from life of the head and arm: broad masses of shadow only to be indicated.

The examination or test of the candidate at the College consists of :—

(1.) A drawing of a figure from the nude about one-third life dimensions.

(2.) A drawing in charcoal of a head from life.

Time for each of these drawings, 6 hours.

For the School of Sculpture and Modelling.

Entrance Test for School of Sculpture and Modelling.

The works to be submitted by a candidate, are :—

(1.) A drawing from the antique.

(2.) A drawing from life.

(3.) An anatomical rendering in pencil (bones and muscles) of No. (2.).

The above figures to be about one-third life dimensions.

The examination or test of the candidate at the College consists of :—

Modelling a bust from the antique.

Time allowed: 6 days.

CONDITIONS OF GRANT OF FULL ASSOCIATESHIP.

10. The Full Associateship of the College is granted to students of the Upper Division who, having been in that Division for at least two consecutive years, pass, within the three years following consecutively, through the four Schools of the Upper Division, and execute a composition for a given decorative subject to the satisfaction of the Council,

10*a*. The grant of Full Associateship will also be considered in respect of students who fulfil some part of the foregoing conditions.

10*b*. The Full Associateship will also be granted to those students who have passed satisfactorily through at least two years' training in the College (or National Art Training School) before October, 1900; have obtained the Art Master's Certificate, Group I.; and two Certificates of other groups.

CONDITIONS OF GRANT OF SCHOOLS ASSOCIATESHIP.

11. The Schools Associateship is granted to students of the Upper Division who, having elected to specialise in one or more Schools of that Division, have been in that Division for at least two years, pass to the satisfaction of the Council, within a period not exceeding five consecutive years in all, the course of studies prescribed for the selected School or Schools of the Upper Division in which they are specialising, and execute a composition for a given decorative subject.

Privileges of Associates.

12. Students gaining the Full Associateship of the College are entitled to wear a hood and gown, and to use after their names the letters A.R.C.A. (London). Students gaining the Schools Associateship are entitled to wear a hood and gown, and to use after their names the letters A.R.C.A. (London), with the title of the School or Schools of the Upper Division in which they have specialised, *e.g.* A.R.C.A. London (Architecture).

13. Applications for the Diploma of Associateship should be made to the Secretary, Board of Education, South Kensington, London, S.W.

CRAFT CLASSES.

14. As a rule, instruction will be given to selected students of the Upper Division in Etching and Engraving, Stained Glass, Pottery, Writing and Illumination, Embroidery and Tapestry Weaving, Carving in Stone, Marble and Wood, Furniture Decoration and Gesso Work.

The special object of the Craft Classes is to afford students the opportunity of working out one or more of their decorative designs in the materials for which they are intended. Before entering any of these classes students

14—*cont.*

must first obtain the permission of the Principal, and they must either be students in the School of Design or have already passed through that School.

15. The times when the Craft Classes meet are posted in the College.

16. Admission to these classes, independently of the College courses, may be granted to a limited number of qualified persons—other than students of the College—who have been specially recommended by the Principal. The fee per term is £2 2s. for each class.*

STUDIES IN THE VICTORIA & ALBERT MUSEUM.

Groups of students will study at appointed times in the Museum, under the guidance of the Assistant Instructor of the Division in which they are working. **Museum Studies.**

TIMES OF STUDY AND VACATIONS.

17. The annual session consists of two terms; the first term begins on Wednesday, October 7th, 1903, and ends on Friday, February 19th, 1904; the second term begins on Monday, February 22nd, 1904, and ends on Friday, July 8th. The Christmas and Easter holidays respectively are from Wednesday, December 23rd, 1903, to Wednesday, January 6th, 1904 (inclusive), and from Wednesday, March 30th, to Wednesday, April 13th, 1904.

18. The day classes meet from 9.30 a.m. to 3.30 p.m. with an interval of one hour for refreshments. The evening classes meet from 5 p.m. to 7 p.m.

19. Students are required to attend every week day, except Saturday, both morning and evening, and to follow the courses of study laid down for them.

20. A register of students' attendance is kept by the Registrar, and may be consulted by parents and guardians at his office. For further information application should be made to the Registrar, Royal College of Art, South Kensington, London, S.W.

COLLEGE EXAMINATIONS.

21. The work of the students is reviewed during each term, and the award of travelling scholarships and prizes is made at the end of each session by the Council on the

* Cheques and Post Office Orders should be made payable to the "Board of Education, South Kensington" or Order, crossed "Account of Payees—not negotiable."

21—*cont.*

work of the session. For all purposes the students' work will be judged by its general quality throughout the session.

22. Students of the Royal College of Art will not be eligible to take part in the National Competition of Schools of Art and Art Classes.

Studentships in Training.

23. A limited number of Studentships in Training at the Royal College of Art are open to competition among registered Art students, who hold the Art Master's Certificate, Group I., and are preparing to become teachers, to enable them to enter the course for the Full Associateship.

24. An applicant for a Studentship in Training must be recommended by the Managers of his or her School of Art. The application must be made on Form 488, which must be sent to the Board with the works (*see* foot note) in support of the application, before the 15th January or the 1st July.

25. The holder of a Studentship in training is entitled to a maintenance allowance at 25s. a week for a term of about 20 weeks; and third-class railway fare for one journey to and fro, each *session*, between the home of the student and London. The student must attend the course of instruction for the Full Associateship, and may be required to perform certain duties as Teacher at the College. Should a Student in training be required to assist in teaching in the College, he will receive while so employed an additional weekly payment of 5s. He is not at liberty to accept a post outside the College without first obtaining the consent of the Principal of the College.

26. Allowances to Students in Training are renewable from term to term, but are only renewable provided that the attendance and progress of the Student are entirely satisfactory. In no case will they be paid for more than five years. Applications for renewals must be supported by the recommendation of the Principal on Form 488A.

Note.—The works to be submitted by a candidate must be carefully selected by him to show his proficiency in the more advanced branches of Art, in subjects beyond those required for the Art Master's Certificate, Group I. They should consist of Drawings, Paintings, and Models from the Antique and the Life, Designs and Working Drawings for Ornament, Decoration and Architecture; and Ornamental and Architectural Measured Studies, including full-sized mouldings; not more than three works in each of these divisions may be submitted.

Royal Exhibitions, National Scholarships, Local Scholarships and Free Studentships.

27. Royal Exhibitions, National Scholarships, Local Scholarships, and Free Studentships are open only to British subjects, and the Board may refuse to award them to persons whose financial circumstances do not warrant such aid. The foregoing exhibitions and scholarships can only be held concurrently with scholarships granted by County Councils, with the express sanction of the Board, who will consider the reasons urged. The Board may withhold any of these awards should the standard of the candidates' attainments be unsatisfactory, or may transfer them to other groups in the current competition. **Persons ineligible for the above.**

27*a*. Where the conditions of Exhibitions or Scholarships have been modified, the interests of existing Exhibitioners and Scholarship holders will not be adversely affected.

28. There are tenable at the Royal College of Art twenty Royal Exhibitions—ten open each year—Twelve National Scholarships—six open each year—and Forty-five Free Studentships—fifteen open each year. **Number of Scholarships, etc., awarded.**

There are at present seventy-two Local Scholarships tenable for three years at Schools of Art under the Board; twenty-eight such Scholarships will be awarded in 1904.

29. The award of all the Exhibitions, Scholarships, and Studentships is made on the results of the Evening Examinations of the Board for the current year and previous successes are not counted. The Exhibitions, Scholarships, and Studentships are held on the condition that the holder attends the prescribed course of instruction regularly, complies with all the rules, and passes the prescribed examinations. **Conditions of Award.**

30. Competitors for Royal Exhibitions, Local Scholarships, National Scholarships, or Free Studentships must arrange before March for their examinations (see § 65 at page 22 of Regulations for Evening Schools, Technical Institutions, and Schools of Art and Art Classes), and must send in Form 1181 before the 15th April, and Form 1202 before the 10th June. **Method of Application.**

Students in Training are not eligible for Royal Exhibitions, National Scholarships, or Free Studentships.

A candidate who has held either a Royal Exhibition, a National Scholarship or a Free Studentship, is ineligible to enter into further competition for these rds. No candidate can hold concurrently a al Exhibition and a National Scholarship, and **Scholarships, etc., may not be held twice or concurrently.**

30—*cont.*

no Local Science and Art Exhibitioner can hold concurrently a Royal Exhibition, a National Scholarship, or a Free Studentship.

Emoluments of Royal Exhibitions.

31. A Royal Exhibition entitles the holder to an allowance of 25*s.* a week for the session of about forty weeks each year for two years, and free admission to lectures and instruction during the course for the Associateship in the Royal College of Art. As a student of the College a Royal Exhibitioner may become eligible for the award of a Royal College of Art Scholarship, in respect of the course for the Full Associateship or that for the Schools Associateship.

Emoluments of National Scholarships.

32. A National Scholarship entitles the holder to an allowance of 25*s.* a week for the session of about forty weeks each year for two years, free admission to lectures and one or more of the technical classes, and instruction in one of the four Schools of the College:

(i.) Design and Ornament.
(ii.) Architecture.
(iii.) Modelling.
(iv.) Drawing and Painting.

with such other supplementary instruction as may be approved.

Persons eligible for National Scholarships.

33. The competitor for a National Scholarship must be a registered Art student engaged in a trade which depends upon Decorative Art; and as a student in the College may become eligible for the award of a Royal College of Art Scholarship in respect of the course for the Schools Associateship.

Should a Royal Exhibitioner, or National Scholar, or Royal College of Art Scholar be required to assist in teaching in the College, he will receive, while so employed, an additional weekly payment of 5*s.*

Emoluments of Free Studentships.

34. A Free Studentship entitles the holder to free admission for two sessions to the lectures and instruction in one of the following Schools of the College:

(i.) Design and Ornament.
(ii.) Architecture.
(iii.) Modelling.
(iv.) Drawing and Painting.

with such other supplementary instruction as may be approved.

It may be renewed exceptionally for one, two or three sessions

Travelling Allowances to Scholars etc.

35. Third-class railway fare is allowed by the Board for one journey to and fro each session, between the home of the Royal Exhibitioner or National Scholar or Royal College of Art Scholar and London. Third-class railway fare is allowed by the Board for one journey to London to holders of Free Studentships upon their taking up their Free Studentship.

Emoluments and Conditions of Local Scholarships

36. A Local Scholarship is tenable for three years with an allowance of 20*l.* a year, at any School of Art under the Board, which is open at least three days and five nights a week, and which will remit the fees for instruction of the holder, or subject to §7 of this prospectus (p. 230), at the Royal College of Art. The scholar must attend a School of Art during at least 40 weeks in the year for 30 hours each week, of which 18 hours at least must be in the day. The Scholarship commences on the date at which the school where the Scholarship is tenable reopens after the summer vacation in each year. The allowance is paid quarterly, on the receipt of a certificate from the Master and Secretary of the School of Art (in the case of scholars attending the Royal College of Art from the Principal and Registrar) that the scholar has attended regularly and pursued his studies satisfactorily.

Persons ineligible for Local Scholarships

A candidate who has held a Local Scholarship is ineligible to compete for it again.

Competition for Royal Exhibitions and Local Scholarships

37. For Royal Exhibitions and Local Scholarships candidates may sit for examination in any or all of the following subjects except when two examinations are held on the same evening, and when there is a Stage 2 and Honours in a subject, in which latter case one or other only may be taken.

The maximum number of marks obtainable in each subject towards these Exhibitions and Scholarships is :—

100 each.

Freehand Drawing of Ornament in outline.
Model Drawing.
Drawing in Light and Shade from a Cast.
Perspective.
Anatomy.

150 each.

Principles of Ornament.
Architecture.
Painting Ornament.
Painting Still Life.

37—*cont.*

200 each.

Historic Ornament.
Drawing the Antique from Memory.
Drawing from the Antique.
Modelling from the Antique.

250 each.

Drawing from Life.
Modelling from Life.
Design (Stage 2).
Modelling Design (Stage 2).

300 each.

Architectural Design.
Design (Honours).
Modelling Design (Honours).

Competition for National Scholarships and Free Studentships.

38. For National Scholarships and Free Studentships the subjects for competition are divided into four Groups, as follows :—

GROUP A.—DESIGN AND ORNAMENT.

	Maximum marks obtainable.
Geometry	100
Plant Drawing from Memory	100
Principles of Ornament	150
Painting Ornament	150
Historic Ornament	200
Design (Stage 2)	250
or	
Design (Honours)	300

Candidates cannot sit for both the Stage 2 and Honours.

GROUP B.—ARCHITECTURE.

Geometry	100
Perspective	100
Freehand Drawing of Ornament in Outline	100
Drawing in Light and Shade from a Cast	100
Architecture	150
Historic Ornament	200
Architectural Design	300

GROUP C.—MODELLING.

Freehand Drawing of Ornament in Outline	100
Drawing in Light and Shade from a Cast	100
Modelling from the Antique	200
Modelling from the Life	250
Modelling Design, Stage 2	250
or	
Modelling Design, Honours	300

Candidates cannot sit for both the Advanced Stage and Honours.

38—*cont.*

GROUP D.—DRAWING AND PAINTING.

Plant Drawing from Memory	100
Model Drawing	100
Drawing in Light and Shade from a Cast	100
Geometry	100
Perspective	100
Anatomy	100
Painting from Still Life	150
Painting Ornament	150
Drawing from the Antique	200
Drawing from Life	250

A candidate may not compete in more than one Group and must state beforehand the Group in which he elects to compete. He may take all the subjects in the Group.

Computation of Marks in all Competitions.

39. In all the Competitions the position of each candidate is determined by the number of marks gained by him in each subject he attempts, diminished by the number required to pass in that subject.

40. Of the six National Scholarships which are offered each year for competition, one at least will be allotted in each of the four Groups A. to D.

Three Free Studentships are allotted each year for competition in each of Groups A., B., and C., and six for competition in Group D.

LOCAL EXHIBITIONS.

Local Exhibitions.

41. Free instruction is given to Local Exhibitioners who attend the College. The rules under which Local Exhibitions to which the locality contributes 25*l.* and the State 25*l.* are granted will be found in the Regulations for Evening Schools, Technical Institutions, and Schools of Art and Art Classes, pp. 26–28.

The conditions under which Local Exhibitioners are admitted to the College are stated at §7 of this prospectus (p. 230).

REWARDS TO STUDENTS IN THE ROYAL COLLEGE OF ART.

SCHOLARSHIPS.

Conditions and Emoluments of R.C.A. Scholarships

42. As soon as the expiry of Studentships in Training and National Scholarships which have been awarded under previous conditions permits, the following Scholarships will be awarded to Students in the College :—

(*a*) Thirty-two Royal College of Art Scholarships of 25*s.* [redacted] week. These Scholarships will be tenable for a term, may be renewed for further terms No renewal can

42—*cont.*

be made to a student beyond the term in which he completes a period of five years' free tuition at the College. From ten to fifteen† Scholarships will eventually be awarded annually. During the period in which a senior Royal College of Art scholar assists in the teaching at the College he may be granted an extra 5*s.* per week. Third class railway fare for one journey to and fro each session between the home of the R.C.A. Scholarship holder and London will be allowed.

Persons ineligible for R.C.A. Scholarships.

Students holding Studentships in Training are not eligible for Royal College of Art Scholarships.

Students gaining Royal College of Art Scholarships cannot hold them concurrently with Royal Exhibitions or National Scholarships.

Method of Award for Students of Full Associateship Course.

In the case of a student who has entered for the Full Associateship Course, the qualifications for the award of these R.C.A. Scholarships are that :—

(1.) He shall be a Student of the College.

(2.) He shall have passed through a two years' course in the four Schools of the College.

(3.) He shall be recommended by the Principal and Professors after their examination of his work in that course.

In the case of a student who has entered for the Schools Associateship Course, the qualifications for the award of these R.C.A. Scholarships are that :—

Method of Award for Students of Schools Associateship Course.

(1.) He shall be a Student of the College.

(2.) He shall have passed the course of instruction in the School or Schools of the College which he has attended for two years.

(3.) He shall be recommended by the Principal and the Professor of that School or Schools after their examination of his works in that School or Schools.

Junior Scholarships.

(*b*) Four Junior Scholarships of 15*l.* a session each, tenable by the student for one session only, will be awarded to the four best free or fee-paying students in their first or second year in the College.

A Junior Scholar receives one moiety of his Scholarship at the commencement of the session, and the balance at the end of the session, provided all the conditions have been fulfilled.

† At present these Scholarships can only be awarded in such numbers as the transitional arrangements permit.

43. The changes indicated above will be made gradually in order that the interests of students, holding National Scholarships and Studentships in Training granted under former rules, may be duly guarded.

Royal Exhibitions, National Scholars, and R.C.A. Scholars.

44. In their last term of attendance at the College students in receipt of maintenance allowances, who are specialising in one or two of the schools of the College, may be allowed to do their own work in the afternoons either in the College or outside, and to take advantage of opportunities of establishing relations with manufacturers and others engaged in practical work.

PRIZES.

Certificates of Merit.

45. Certificates of Merit (first and second class) may be awarded to students in the Upper and Lower Divisions who are reported to the Board to have passed satisfactorily through each school of the division.

Prizes in Upper Division.

46. The following prizes may be awarded annually, upon the recommendation of the Council, to successful students in each school of the Upper Division:—

Travelling Scholarships.

(*a*) A Travelling Scholarship of £50 to the best student who has been at least two sessions in the Upper Division of the College.

The period during which such students are abroad will not count as a portion of the time during which a student is entitled to hold a Scholarship or other corresponding privilege in the College.

A student can only once hold a Travelling Scholarship.

(*b*) One prize of books, materials, etc., to the value of £6, one prize to the value of £3, and five prizes to the value of £1 each, to students in order of merit other than those gaining the Travelling Scholarships.

Prizes in Lower Division.

47. The following prizes may be awarded annually, upon the recommendation of the Council, to students in each school of the Lower Division:—

One prize of books, materials, etc., to the value of £4, one prize to the value of £2, and five prizes to the value of £1 each, to the best students in order of merit.

Special Prize.

48. The Council may recommend that one special prize of the value of £5 be given each session to the student who shows conspicuous ability in two or more of the schools of the College.

rizes may ot be had wice.

49. Students who have received a prize in any school of the College are debarred from afterwards receiving a prize of the same or lower value in the same school of the same division. It must be borne in mind that in awarding Scholarships and other prizes the general conduct and punctuality of students will be taken into consideration.

Regulations to be observed by Students.

(1.) All students must enter daily the times of their arrival and departure; books for this purpose are kept in the hall.

(2.) Students are allowed from 12.30 to 1.30 p.m. for lunch, and no student may absent himself for a longer time or during College hours, without permission.

(3.) In case of absence from any cause a communication must be sent at once to the Registrar. When absence on account of illness exceeds two days a medical certificate is required, which must be sent to the Registrar, Royal College of Art, South Kensington, S.W.

(4.) After absence, from illness or other cause, students must, on their return to the College, report themselves to the Registrar.

(5.) Students who have been directed to work in the Museum or other places will be given a written authority which must be left with the Attendant at the entrance of the College.

(6.) No student is allowed to remain in the College after working hours.

(7.) All applications for special leave must be made in writing to the Registrar.

(8.) Any change of address must be at once intimated to the Registrar in writing.

(9.) Each student on registration will be handed a ticket of admission which must be produced when required. If re-admission is sought by a student this ticket must be handed back in exchange for a new ticket. If a ticket be lost, the Registrar should at once be informed in writing, when a Pass will be issued.

49—*cont.*

(10.) The Board cannot be responsible for the custody of the private property of students, nor can any claim be entertained in respect of any articles that may be left in the College. Each student is provided with a locker for which a padlock and key may be supplied by the student.

(11.) It is the duty of all students to read and comply with any official notices which may be posted in the College.

(12.) Communications to the Royal College of Art should be addressed to

The Registrar,
Royal College of Art,
South Kensington,
London, S.W.

SUMMER COURSES FOR TEACHERS.

Short Courses of Instruction in Art.

The details of the arrangements in paragraph 50 are subject to revision from year to year.

50. The Short Courses of Art Instruction for Art Masters and Mistresses, Elementary School Teachers, and Students of Schools of Art and Art Classes, will be held at the Royal College of Art in July. The courses will include (I.) Classes for instruction in Drawing and Modelling from the Life, in Anatomy, and in Design; (II.) Demonstrations upon Figure Composition as applied to Mural Decoration by Professor Moira, which will be given in the Lecture Theatre of the Victoria and Albert Museum; upon Figure Composition in Relief by Professor Lantéri: and Blackboard Demonstrations by the Principal and others, upon subjects suitable for Primary Drawing in Elementary Schools, which will be given in the Class Rooms of the College; (III.) Lectures upon the History of Antique Figures in use in Schools of Art by Mr. B. A. Spencer; upon the Teaching of Design by Professor Lethaby; and upon the past session's work of the Architectural School by Professor Pite, which will be given in the Lecture Theatre of the Museum; and (IV.) Study in the eum.

51. Applications to attend these Courses will be entertained *only* from those Art Teachers and Students who have obtained awards in the National Competition or successes in the advanced Art Examinations, or have had works accepted for the Art Master's Certificate, Group I.: and from Elementary School Teachers who are recommended for the Primary Drawing Course.

52. Application to attend must be made on Form 234, before the 10th June.

53. Applications from Teachers and Students in Scottish Schools of Art and Art Classes must be addressed to the Secretary, Scotch Education Department, 55, Whitehall, London, S.W.

54. Applications from Teachers and Students in Irish Schools of Art and Art Classes must be addressed to the Secretary, Department of Agriculture and Technical Instruction, 4, Upper Merrion Street, Dublin.

55. Applicants who are selected to attend these Courses will receive third-class railway fare (*see note below*) for one journey to and fro between their homes and London, and £3 towards their expenses while attending the courses, provided that their attendance is punctual and their work is in all respects satisfactory. In the case of Teachers or Students resident in London or its vicinity, a reduction is made in the grant.

Students attending the Summer Courses will be expected to provide themselves with the requisite materials and apparatus, of which a list will be sent to them.

NOTE.—All selected applicants are required to travel by the cheapest route and to use return tickets whenever a saving can be effected thereby. In all cases only the amount actually disbursed for travelling expenses, within these limits, is to be claimed No cab or omnibus fares will be allowed.

SESSION 1903–4.

SYLLABUS

OF

THE COURSES OF INSTRUCTION.

ARCHITECTURAL COURSE.

Professor—A. BERESFORD PITE, F.R.I.B.A.

Assistant Instructor—CHARLES DE GRUCHY.

Architectural Course, General Scheme.

The general scheme of the School provides for the study of architecture as a practical building art, and consists of the following courses:—

INTRODUCTORY COURSE.

To be passed by students who are passing through all the four Schools, except such as are qualified to be placed at once in a higher course of this School.

First term of first year devoted to the study of general principles of architectural design and of the relation of architecture to other arts.

LOWER DIVISION COURSE.

First and Second Year's Course.

Building construction exemplified in the designing and planning of ancient buildings or good modern examples. Simple subjects in design.

UPPER DIVISION COURSE.

Third and Fourth Year's Course.

Advanced Building Construction.—Design of a complete architectural subject worked out practically in drawings allied with work in the School of Crafts.

Fifth Year's Course.

Design of important and ornamental buildings completely worked out in collaboration with advanced students of the Decorative Painting and Sculpture Schools.

Introductory Course.

Architectural Course, Introductory.

The objects aimed at in this course, which does not include constructional and technical subjects, are :—

(*a*) To give a preliminary course for students intending to take up the complete architectural course of the school.

(*b*) To instruct students who will become art masters in the general principles of architectural design, and to indicate directions for further training so as to enable them to comprehend the purposes and methods of architectural study.

(*c*) To deal with the union of the several arts in buildings and the architectural basis of decorative art for students intending to specialise in the other schools of the College.

(*d*) The preliminary course will be available for those about to take up architecture as a profession before entering an architect's office or becoming apprenticed.

The instruction is by courses of lectures and demonstrations by measured studies in the Museum and by simple exercises in design.

Lower Division Course.

Architectural Course, Lower Division.

The complete architectural course for all students who specialise in architecture begins with the lower school, and deals with (*a*) building construction and the qualities of materials allied with and studied in connection with the design of simple buildings; (*b*) the study of practical building construction and of planning for useful purposes being made the basis of the study and practice of design; and (*c*) measurement of example of detail in the Museum, and of complete buildings during the summer term.

Courses of lectures will be given each year upon subjects which will be set in design, dealing with the following heads:—

1. The plan and arrangement of buildings for useful purposes.

2. Construction, dealing with the different trades, nature and specification of materials, principles of sanitation and building regulations.

3. The principles and practice of architectural design and the preparation of drawings.

4. The study of typical ancient buildings, historically and by measurement.

The first year's course deals with (*a*) the principles of design and construction of typical ancient buildings; (*b*) series of measured studies of examples of detail in the Museum, and the collation of examples from the Art Library; (*c*) the design of simple buildings with their constructive details and full-sized mouldings.

The second year's course deals on the same principle with subjects in design involving the complete practical consideration of a modern building such as a town house or small public building, including plan details of construction in the different trades, principles of sanitation, and specification of materials.

Students in this course will be required to follow the demonstrations in those sections of the School of Crafts which are germane to architecture.

Students in the Lower Division will render clerical assistance to advanced students in preparing important designs.

Preparation of working drawings to $\frac{1}{8}$ and $\frac{1}{2}$ inch scales with full size details.

Architectural perspective drawing, and pen and ink and water-colour architectural drawing.

Measured study of complete ancient buildings, conducted by visits from the College under direction.

Simple colour decoration of buildings.

Study of architectural history by directed reading.

Upper Division Course.

The third year's course will deal with the design and working drawings in full detail of an important building, Architectural Course, Upper Division.

such as a large church, a national memorial, concert hall, or a bridge involving special planning, constructive problems, and study of design.

Students in this course will be required to collaborate with advanced students in the Decorative Painting and Sculpture Schools in the employment of mural painting and sculpture in their designs and drawings.

Descriptive specification of materials. Also notes upon typical buildings studied in connection with design.

Clerical assistance will be provided by junior students in the preparation of the finished drawings of each design. The subject set in the last term of the year will be in competition for the annual scholarship prize.

Students specialising in architecture should take during the second term of the first year's course, a course of figure drawing in the evening classes.

All students will be afforded the opportunity of visiting works and buildings in progress, and of coming into contact with actual building work and practical architectural design. Visits to good architectural examples for measurement and sketching will be undertaken during the summer term.

MODELLING SCULPTURE COURSE.

Professor.—E. LANTÉRI.

Assistant Instructor.—B. CLEMENS.

LOWER DIVISION COURSE.

First Year—First and Second Terms.

Modelling Sculpture Course, Lower Division.

Features of the face. Hands, feet of casts from life. Bust from the antique.

Second Year—First and Second Terms.

Figure from the antique. Anatomy of this study. Studies of casts from life—torso, arm, leg, &c. Studies of plants.

Ornamental adaptation of the study; and study of carved and modelled ornament in relation to its place in architecture.

UPPER DIVISION COURSE.

Third Year—First and Second Terms.

Modelling Sculpture Course, Upper Division.

Bust from life. Figure from life.

Composition: figure and ornament in the round and to fill architectural spaces.

A subject will be given every three weeks, and students' work thereon criticised.

During the third year course the following lectures and demonstrations will be given on—

1. The bust from life.

Armature. Building up of a bust in clay. Measurements. Division of forms in the face.

Practical modelling demonstration.

2. The figure from life.

First Lecture—Armature. Pose of the figure. Chief lines. Contrast of lines. Contrast of surfaces. Scale of proportions. Measurements. First practical modelling demonstration.

Second Lecture.—Osteological construction of the figure. Influence of osteology on the superficial forms.

Second practical modelling demonstration.

Third Lecture.—Central points of radiation in Myology. Variety of character of forms. Spaces of rest between each mass. A few comparative proportions.

Third practical modelling demonstration.

Fourth Year—First Term.

Modelling from life, in the round and in relief. Modelling of folds. Arrangement of draperies in the round and in relief. Figure design and ornament. Sketch subject every three weeks. Marble carving (ornament). Comparative anatomy.

During the fourth year course the following lectures and demonstrations will be given:—

1. Relief. Relief is an interpretation of nature. Projections must vary according to their surroundings. How relief must be treated in a study. Superposition of surfaces in the contours. High relief. Half relief. Low relief.

Practical modelling demonstration.

2. Folds of drapery. Characteristic points of the fold. Direction of surfaces of folds.

Practical modelling demonstration.

3. Arrangement of drapery on cast or lay figure. Drapery must contribute to explain the movement of the figure. Chief line of drapery. Masses of folds. Points of radiation of folds. Points of rest between each mass.

Practical demonstration on the arrangement of drapery on casts.

Demonstrations will be given of an arrangement of

drapery in high relief, modelled in clay; or the same arrangement in *low relief;* and of figure and ornamental design for architecture and art manufacture—Medallions, medals, plaques, &c., Marble carving (pointing).

Fifth Year—First and Second Terms.

Studies from life, *life size.* Studies of arrangements of draperies from life. Studies of animals. Figure and ornamental design, *full size.* Special subject given and criticised every six weeks. Carving in marble (figure). Enlargement of figure by pointing. General studies of antique sculpture: figure, drapery and composition.

Practical modelling demonstration of arrangement of draperies from life.

Practical demonstration of enlargement of figure.

Occasional practical demonstrations will be given on *casting*:—

1. Waste mould.
2. Gelatine mould.
3. Piece mould.
4. Piece mould in clay.
5. Clay squeezed into piece mould.
6. Casting from life.

DESIGN AND CRAFTS COURSE.

Professor—W. R. LETHABY.

Assistant Instructor—G. C. BUNNEY.

Design and Crafts Course.

In the school of Design and Crafts practical workmanship in different classes is taken concurrently with the general drawing work of the studio, and every advanced student of design will be expected to make himself proficient in the technique of one craft.

Craft classes are already established in stained glass, wood carving and gesso work; stone and marble cutting, pottery painting, etching, lettering and illumination, tapestry weaving and embroidery.

A limited number of students of craftsmanship not in the College wishing to have instruction in one of these craft subjects can be admitted for that subject only, provided their admission does not interfere with the attendance of students passing through the College courses.

The course of study in the studio and the museums is given below, but it must be taken as suggesting the scope of study rather than [illegible] to be followed in exact sequence.

Every student of design will be required to make a series of *careful* studies in the museums; these should as far as possible be uniform in size for ready reference.

All advanced students of design will be expected to specialise their studies with a view of perfecting themselves in one branch of art and coming into touch with special forms of industry. Such special knowledge will be equally valuable to the teacher and the designer.

The following subdivisions are suggested, but there may be some interchange of studies:—

I. Decoration, stained glass, mosaic, tapestry, &c., involving figure composition.

II. Cabinet work, house decoration, pattern painting, stencils.

III. Pottery and porcelain design, majolica, &c.

IV. (*a*) Printed stuffs, Wall papers, &c. (*b*) Textiles, Embroidery, Lace, Carpets, and Damasks.

V. Gold and silversmiths' work, Jewellery, Enamelling, &c.

VI. Modelled and carved ornament in stone, wood and plaster, gesso work and gilding.

VII. The book and its decoration, illustrations, borders, type, initials, title pages; illumination and lettering, wood engraving, photographic reproduction, lithography, etching; bookbinding, cloth covers.

VIII. Metal work in wrought and cast iron, lead, brass, &c.

Lower Division Course.

First Year.

Design and Crafts Course, Lower Division.

An introductory course in design, based on the following syllabus, will be taken in the first year's work in the Designing School, and special attention will be given to the following subjects as preliminary to the full course.

Copying of fine examples of ornamental drawing and design. Drawing from casts of selected ornament in pencil and pen and with the brush. Drawing to a large scale on dark paper in chalk. Memory drawing of flowers, &c.

Brush work in symmetrical patterns, making the most of the characteristic strokes of the brush. The same, translating natural forms into free brush work and arranging them to fill given spaces.

Studies from Nature to be very carefully made fr[illegible]m flowers, foliage, butterflies, shells, wings, and other comm[illegible]on and natural objects, and from photographs. Structure [illegible]to be specially observed and refinement of drawing aimed at[illegible]t.

Second Year.

Same work continued.

Brush work applied to pottery painting and similar form[illegible]ms of design.

Studies from Nature to include reference to Botanica[illegible]cal and Natural History Books, old Herbals, &c.

Black and White copying of fine examples of illustratio[illegible]n, and engraving, studies from flowers and other objects in pe[illegible]en and ink.

Conditions of Pattern Design. Repeats as in a frieze, o[illegible]or every way as in a wall paper; usual sizes of repeats i[illegible]in printed and woven stuffs.

Development of Pattern Design, spaces divided into strip[illegible]ips and meshes; counter-changing of black and white spaces, [illegible]es, powderings.

Lettering in pen and brush work copied from fine examples.[illegible]les.

Study of old examples in Museum making careful draw[illegible]w- ings of objects selected by the Professor.

Designing, simple exercises in.

Students may join the Craft Classes by special permission. [illegible]o

Upper Division Course.

Third Year.

n and

e, Upper on.

Same work continued but with more special application to one of the branches of Design. Students will join one of the Craft Classes.

Studies from Nature, Birds and animals to be studied in Natural History Museum.

Life and Costume.

Black and White, objects in the Museums, draperies, etc., to be studied in pen and ink.

Mechanical Conditions of Design, materials and methods of production.

Development of Pattern Design, sprigs, scroll patterns, knot work and labyrinthine patterns, borders, crestings, etc., showing how these elements apply to different materials.

Lettering, etc., text writing, ornamental initials, and decorative pages, illumination, proper place of type on the page.

Study of old examples in the Museum, mainly illustrative of the special branch of design selected by the student.

Literature of Art, work in library, history of selected branch of Art.

Original Design, subjects to be worked out in consultation with the Professor.

Fourth Year.

Same work continued.

Museum Studies, with special relation to aptitudes and limitations of given materials and the historic development of crafts.

Figure Composition for given situations and materials.

Heraldry, study of the principles of, and practice of a good type of heraldic drawing.

Lettering. Inscriptions in given materials, on scrolls, monograms, cyphers, &c.

Symbolism, etc., introduction to, and other accessory material for design, badges, insignia, ships, flags, crowns, armour, the zodiac.

Original Designs.

Fifth Year.

Original designing and craftsmanship in Craft Classes.

As far as possible students of the fifth year will be afforded facilities for getting into touch with manufacturers.

MURAL AND DECORATIVE PAINTING COURSE.

Professor—GERALD E. MOIRA.

Assistant Instructor—E. C. ALSTON.

LOWER DIVISION COURSE.

First Year—First Term.

Decorative Painting Course. Lower Division.

Antique School. Heads, hands and feet, Torso, drawn and shaded in charcoal or point. The same anatomised.

No outlines apart from shade or shadow.

Evening School: Four-hour studies from the antique in charcoal or point. Drawings to be not less than Imperial size.

First Year—Second Term.

Figures to be drawn in five days in charcoal or point; the same figure to be anatomised.

No outlines apart from shade or shadow,

Evening School: Same as First Term.

Second Year—First Term.

ANTIQUE CLASS.

Figures painted in monochrome. Time allowed, 14 days. Studies of drapery arranged on the Antique to be executed in charcoal, point, or monochrome.

Studies of Still Life: Medium, oil or tempera.

Evening School: Details of the figure, heads, hands and feet drawn from the life in charcoal or point.

Second Year—Second Term.

Studies of details of the figure: Heads, hands and feet from the life in charcoal or point. Time studies from the nude to be executed in charcoal or point. Drawings to be not less than Imperial size. Studies of drapery arranged on the living model.

Still life painting in oil or tempera.

Evening School: Time studies from the nude, executed in charcoal or point. Studies not to be less than Imperial size.

UPPER DIVISION COURSE.

Third Year—First Term.

Decorative Painting Course, Upper Division.

Drawing from life in charcoal. Painting from same model in same pose as used in the drawing.

Simple compositions to be executed in charcoal from the above figure, which will be posed with the intention of decorating a given space.

Studies of drapery executed in charcoal, the drapery being arranged by the students under the supervision of the Professor.

Models posed for eight days. Time allowed for figure composition, four days.

Students attending this course will be required to attend the Evening Life School at least four evenings a week.

Painting still life as compositions of colour on a large scale. Groups to be arranged by students under the supervision of Professor.

Third Year—Second Term.

Figure Drawing and Painting, the model always being posed by the student with the intention of decorating a given space. Time allowed, eight days.

A figure subject will be given based upon the figure or figures suitable for some given space, such as a panel, lunette, spandril, triangular space, &c. The rules of composition applicable in each case being explained. The drawing to be executed in charcoal.

Studies of drapery arranged on the living model by the student to be executed in charcoal.

Evening School: Time Studies to be executed in charcoal or point. Drawings not less than Imperial size.

Studies of drapery arranged on the living model to be drawn in charcoal or point.

Fourth Year—First Term.

Drawing and painting from the life. The figure to be posed for eight days, from which a painting will be executed in oil or tempera.

The subject of the figure composition will be announced and the figure posed to meet as nearly as possible its requirements. Four days will be allowed for the composition, the dimensions of which will be given and its intended position stated; so that no composition will be executed without due regard being given to its fitness as an architectural decoration, and especially the scale of figures in relation to the spaces for which they are intended.

These compositions will be executed in charcoal and the most successful will be carried out in colour with a medium selected by the Professor, which may be tempera, oil, or paraffin wax.

Studies in drapery to be executed in charcoal or colour, at the discretion of the Professor. Disposition of the folds to be arranged by the students under the direction of the Professor.

Fourth Year—Second Term.

The work of this term will be a continuation of the above and according to the progress made by the students and their ability to cope with the composition of important subjects, so the time for this work will be extended.

Evening School: Life studies from the nude, time allowed two hours, to be executed in charcoal or point.

Fifth Year—First and Second Term.

Drawing and painting the figure. Students in this year will be required to undertake larger schemes of mural

decoration, and with this end in view will be required to colour their cartoons, which may be their own designs, with a view to their execution in some definite material. The students may be required to assist in carrying out large schemes of decoration in the whole or part of a building, and must be prepared to work for various media.

Evening School: Same as in Fourth Year.

METHODS OF TEACHING COURSE.

The Principal and Head Master—A. SPENCER.

thods of aching urse.

The instruction given in methods of teaching will relate to the art instruction recognised by the Board of Education, *i.e.*, from Drawing in Elementary Schools to such work as that done in Schools of Art for Advanced and Honours Examination and for the National Competition. The period of training in the methods of teaching will spread over the whole course of a student's college career, so that when the student leaves to become a teacher he may be prepared to grapple with the various points that may arise in dealing generally with Art instruction.

Students who enter the College with the intention of becoming teachers will be required to attend lectures given by the Principal on Methods of Teaching, and, as part of their training, to give instruction in the College under his direction.

These students, according to their various years, will be required to give demonstrations either on paper or on the blackboard; and, in order to prepare them for this work, the Principal, on four evenings a week, will give instruction on Methods of Teaching.

The Instructor responsible for the Evening School will be assisted by Teachers-in-Training in taking charge of the Life and Antique Classes, according to their years. The pose of the model, and the antique figures to be drawn, will be decided upon at a morning lesson, when the work also will be arranged for the evenings of the following week. The student in charge will be required to give a demonstration before the class, and in presence of the Principal, of his method of commencing a figure and of carrying it through to the blocking in of the broad masses of shadow.

First Year.

Students in their first year will be required to attend a class on one evening a week on blackboard demonstration. Such subjects will be taken as would prove suitable lessons

for Kindergarten instruction. This class will be held in presence of the Principal by a Student-in-Training in his second year; ten such second year students will be required each to give four consecutive demonstrations in the course of the year.

Second Year.

Students in their second year will be required to attend an evening class on blackboard demonstration. The lesson will be of such a character as would be suitable for the instruction of drawing in Elementary Schools. Ten third-year students will be required each to give consecutively four of these demonstrations in the course of the year, and in presence of the Principal.

Third Year.

Students in their third year will be required to attend a class, conducted by students in their fourth and fifth year, on Methods of Teaching subjects contained in the various syllabuses issued to Art Schools by the Board of Education.

Fourth and Fifth Years.

Students in their fourth and fifth year may be required to give, in the presence of the Principal, lectures on various subjects bearing upon Art, such lectures being attended by the whole of the Lower School.

For the above lessons teachers may create their own copies or they may work from the Illustrated Elementary Drawing Syllabus issued by the Board of Education as well as other Syllabuses.

The Principal will devote one evening a week to Teachers-in-Training in order to help them in preparing the lessons which they are to give in the Evening School.

The teaching power of each Teacher-in-Training will be taken into account in awarding Travelling Scholarships and other prizes; and any Teacher-in-Training who does not show a capacity for teaching will not be allowed to remain in the College as such.

LITERARY COURSE.

Lectures are delivered on the General History of Art, together with that of special periods such as:—Greek and Roman Sculpture, Early Christian Art, Painting and Sculpture in Italy during the Renaissance, the Northern Schools of Painting, and various Crafts.

With special reference to Figure Composition, lectures ·red on Classical Antiquities, Greek and gy, and the costumes of various periods.

ETCHING AND ENGRAVING SCHOOL COURSE.

Teacher—FRANK SHORT, R.E.

Etching and Engraving Course.

Students in this class are required to work practically at one or more of the following methods of engraving, viz.:—

Etching.
Aquatint Engraving.
Line Engraving.
Mezzotint Engraving.
Relief Engraving.
Steel-facing and Plate printing.

Tools and materials are provided.

STAINED GLASS COURSE

Teacher—C. W. WHALL.

Stained Glass Course.

The students being already trained Draughtsmen and Painters, the teaching is mainly directed towards the acquirement of a knowledge of the craft, and especially of craft limitations as affecting design and execution.

The actual technique of painting and lead-working are therefore taught in the ordinary class lessons, and the direction and application of them in the special weekly lecture or demonstration.

In General.

The past history and place of Stained Glass in the Architectural Arts. The present conditions under which it is produced. Apprenticeship. Subdivision of labour. The possibilities of employment. The uniting of design and execution. Architectural fitness. Poetic and imaginative fitness.

In Detail.

Stained Glass essentially an Art of the Middle Age. The Gothic revival—its effects—its defects—its present influence. The revival of craft—the master craftsman—his present position and opportunities—technical knowledge, perfection of each branch of it in modern work, but subdivided. The separation of design from [illegible]—their reuniting in Art and Craft. Technique.

Second Course.

Decoration by painting with underglaze colours, and coloured glazes.
Hardening—Glazing.
Firing Glazed Ware.
Decoration by painting in overglaze, or enamel colours.
Firing Enamel Kiln.
Della-Robbia Ware—Majolica—Oriental tiles and shapes, showing their method of production.

WRITING AND ILLUMINATION COURSE.

Teacher—E. JOHNSTON.

Writing and Illumination Course.

a. The acquiring of a formal hand (founded on early writings).

This gives an insight into the construction of letters, and indicates how new forms may be designed. The pen being essentially a letter-making tool, and writing the medium by which nearly all forms of letters have been evolved.

b. The practical application of writing.

This inculcates right methods in the spacing, arrangement and combination of Letters and masses of Lettering, *e.g.* in Addresses, Books, Poems, and other MSS. and in "Bill Heads," Book Plates, "Black and White Work," Title Pages, "Book Decoration" and other printed matter: also in Stone, Metal and Woodwork, and in Handicrafts generally.

c. Theory of Lettering.

The principles underlying the construction and arrangement of good Lettering, arrived at, analytically, by the study of old MSS. and Inscriptions, and, synthetically, by the practice of Writing.

Certain modern degraded forms and why they should be avoided.

Minuscule (small letters) and Majuscule (capitals) Roman, Uncial, Irish, Gothic and Italic forms.

Modification of forms to suit different processes and materials, *e.g.* Stone and Metal engraving, Woodcarving, pen versus brush work.

d. Gold-laying and burnishing in MSS.

Composition of "Size" [illegible] and burnishing gold leaf.

e. The Elements of Illumination.

"Rubricating" (*i.e.*, writing in red), Writing and Lettering in gold and colours, Capitals and Initials, Decoration of Initials, etc., Borders and Decoration of Pages.

f. The qualities of good Writing are *Readableness*, *Beauty* and *Character*, and Illumination is the *Decoration of such Writing*. Writing and Illumination form the *necessary foundation* of good Typography and Book Decoration.

EMBROIDERY AND TAPESTRY-WEAVING COURSE.

Teacher—MRS. A. CHRISTIE.

Embroidery and Weaving Course.

I. Needlework.

The study and practice of methods of work in various materials.

Embroidery, appliqué work, open work, etc. Planning and tracing on of patterns. Manipulation of stitches and study of examples in the Museum.

II. Tapestry Weaving.

Stretching warp and weaving small tapestries in silk and wool from the student's own designs.

MARBLE AND STONE CARVING COURSE.

Teacher—A. GALMUZZI.

Marble and Stone Carving Course.

These classes are formed for the purpose of enabling students the better to express their ideas in the materials for which they design in clay, thus giving them a knowledge of the limitations of these materials.

The course of study is divided into *five terms*, which correspond to the College terms.

1st term—Practice in cutting marble and stone from ornament.

2nd term—Finishing carving ornament.

3rd term—Pointing with machine and carving a head in relief.

4th term—Pointing and carving a head in the round.

term — Enlargement with compasses and

FURNITURE DECORATION AND GESSO WORK COURSE.

Demonstrator—G. JACK.

Furniture Decoration, etc., Course.

This class is conducted with a view to giving the students practical insight into methods of obtaining ornament in relief, such as carving in wood and work in gesso. It is intended that decorative colouring as applied to gesso work shall be taken up as soon as the studies in progress are sufficiently advanced.

In so far as it is possible the students are encouraged to develop their own individuality. Students make their own designs for the work they are to carry out, and these designs undergo the teacher's supervision and correction with a view to the practical necessities of the material.

1st. Gesso Work.

2nd. Wood Carving.

3rd. The Inlaying of various Coloured Woods as applied to Cabinet making.

4th. Decorative Painting on Wood in connection with Furniture.

5th. Furniture designing with a view to combining the various kinds of decoration practised by this class.

Honorary Associates.

v F.	JACK, RICHARD.
)HN J.	
	KENNINGTON, THOMAS B.
	KYLE, JOHN.
, R.W.S., GEORGE.	
L., ALFRED J.	LANGLEY, R.I., WALTER.
IAM.	MCKEGGIE, THOMAS.
	MARRIOTT, FREDERICK.
	MORTON, WILLIAM
ALFRED.	OGDEN, JOSEPH.
I.	RHEAD, R.E., GEORGE W.
HN.	ROBERTS, ELLIS.
KE.	SHANNON, A.R.A., JAMES J.
DER.	SIMMONDS, THOMAS C.
	STANNUS, F.R.I.B.A., HUGH.
I.A., RICHARD.	THOMAS, J. HAVARD.
P.R.I., EDWARD J.	THOMAS, WILLIAM G.
	TOFT, ALBERT.
EORGE.	WARD, JAMES.
H.	WOOD, F. DERWENT.
D G.	WOODS, R.A., HENRY.

Associates.

Name.	Sessions in attendance at the College.	Name.
EN, ERNEST L.	1892–98	BAKER, JULIA.
EN, JOHN E.	1869–73	BAKER, THOMAS.
EN, WILLIAM H.	1878–84	BARKAS, HENRY D.
ISON, JOHN W.	1897–00	BAXTER, ARTHUR H.
PORT, HARVEY.	1885–90	BAYNTON, HARRY.
DERSON, JOHN.	1896–99	BEARDER, HIRAM W.
	1854–61	BENTLEY, JOHN.
MSTRONG, FREDERICK	1857–61	BIRKMYER, JAMES.
V.	1878–82	BLACK, FRANCIS.
IERTON, JAMES.	1897–02	BLACKLOCK, WILLIAM K.

Sessions in attendance at the College.	Name.
1898–03	BLATCHFORD, JOHN C.
1898–02	BLAYLOCK, THOMAS P.
1899–02	BOASE, GEORGE F.
1860–65	BOONE, WILLIAM A.
1865–70	BRADBURY, ALFRED A.
1855–60	BRENAN, JAMES.
1857–59	BROPHY, NICHOLAS A.
1891–95	BROWN, EDWARD A.
1895–00	BROWN, FRANK H.
1892–97	BROWN, PERCY.
1886–92	BUCKMASTER, MARTIN.
1894–98	BULMER, HUBERT E.
1891–95	BURNAND, VICTOR W.
1891–95	BURRIDGE, FREDERIC V
1894–98	BURT, ARTHUR.
1890–94	BUSH, REGINALD E. J.
1881–85	BUSK, WILLIAM.
1888–91	BYGATE, JOSEPH E.
1859–65	CAMPBELL, JOHN A. D.
1885–91	CAREW-SMYTH, PONSONBY M.
1886–91	CARTLIDGE, GEORGE.
1874–81	CARTLIDGE, SAMUEL J.
1887–92	CHAPLIN, WALTER H.
1892–97	CLIFFORD, HARRY P.
1882–84	COLE, THOMAS W.
1873–80	COLLIER, BERNARD C. C.
1890–92	CONWAY, EMILY J.
1869–74	CORTISSOS, CHARLES.
1887–93	CROMACK, GEORGE H.
1897–01	CORNSHAW, JAMES H.
1874–80	DOUGLASS, THEODORE L.
1892–96	DUNCAN, WILLIAM R.
1898–03	DUFFY, EDITH M.
1893–99	DAWSON, ROBERT A.
1864–69	DAWSON, ROBERT R.
1882–87	DEAN, CHARLES T.
1882–86	DUNLAP, JAMES M.
1866–72	DUMBELL, GEORGE C.
1881–88	EARLES, [illegible]

Sessions in attendance at the College.	Name.
1894–03	EDWARDS, GRACE.
1879–84	ELTON, EDGAR A.
1895–98	EMANS, FRANK.
1898–03	ERWOOD, ADA.
1894–98	EVA, CHARLES A.
1896–03	EVANS, WILLIAM H.
1893–96	FISHER, GEORGE P.
1884–86	FLOWERDEW, CHARLES E.
1861–67	FREETH, JAMES W.
1897–01	FRASER, JOHN P.
1889–92	FRIPP, HENRY C. I.
1890–94	GEORGES, CHARLES E.
1872–76	GIBBONS, EDWARD.
1873–77	GILL, EDWIN R.
1878–82	GILL, HARRY P.
1894–97	GLADWELL, ALLEN R.
1892–97	GRAY, CLAUDE W.
1876–82	GREENWOOD, EDWIN.
1890–94	GRIFFIN, FRANK.
1867–68	GRUBB, WILLIAM M.
1892–97	HALEY, WILLIAM T. H.
1882–87	HALL, PHILIP.
1869–74	HARBUTT, WILLIAM.
1873–80	HARLEY, GEORGE W.
1880–83	HAVELL, ERNEST B.
1895–01	HEARD, NATHANIEL.
1897–00	HEWITT, HAROLD W.
1871–79	HODGES, CHARLES M.
1853–61	HOWARD, VERNON.
1882–89	HUTSON, HENRY.
1859–64	HULME, FREDERICK E.
1888–92	HUNT, HANNAH J.
1884–87	INGLIS, GEORGE S.
1896–02	JACKSON, ARTHUR.
1895–98	JACKSON, BEN L.
[illegible]	[illegible], WILSON.

in nce : e.	Name.	Sessions in attendance at the College.	Name.
0	JAHN, ALBERT C. C.	1878–83	NORRIS, WILLIAM E.
8	JONES, DAVID.	1898–02	NOWILL, FRANK.
1	JONES, HARRY.		
2	JONES, THOMAS.	1896–98	O'SULLIVAN, PATRICK.
4	JONES, WILLIAM.		
2	JULYAN, MARY.	1896–01	PARKINSON, WILLIAM E.
		1890–95	PARKYN, JOHN H. P. W.
3	KAY, ERNEST.	1897–00	PAUL, FREDERICK
0	KEMP, JOHN.	1897–02	PAYNE, ARTHUR E.
2	KENNAWAY, CHARLES G.	1883–87	PEARCE, JOSEPH A.
		1877–82	PERKIN, EMIL S.
3	KENNEDY, JAMES.	1880–82	PERKIN, ISABELL L.
2	KNIGHT, WILLIAM G.	1897–03	PETTINGER, JOHN F.
		1895–00	PITKETHLY, GEORGE R.
5	LANGMAN, ANDREW W. F.	1899–01	POYNDER, ROBERT B.
1		1859–65	PUCKETT, ROBERT C.
)	LEE, JOHN.		
3	LEES, HERBERT.	1880–82	RAIMBACH, DAVID L.
2	LEWIS, ALFRED.	1881–84	RANDERSON, PAULINA M.
2	LINTOTT, HENRY J.		
3	LLEWELLYN, SAMUEL H. W.	1897–03	RAWSON, WALTER W.
		1868–74	RAWSON, WILLIAM.
)	LORD, WILLIAM H. H.	1895–99	REEVES, PERCY O.
5	LOWENTHAL, DORA L.	1883–88	REILY, FRANCIS.
'	LUKE, FREDERICK.	1875–82	RENARD, EDWARD.
		1883–89	RIDER, HAYWOOD.
3	MARPLES, GEORGE.	1895–00	ROGERS, CHARLES H.
)	MARTIN, WILLIAM J.	1887–89	RUSHTON, ALFRED J.
:	MASON, EDITH M.	1897–00	RYLAND, ALFRED L.
)	MAWSON, CLARENCE.		
2	MAY, FREDERIC F.	1896–98	SCHOFIELD, ARTHUR B.
5	MENZIES, JOHN.	1890–95	SCHRODER, HUBERT.
)	MERRITT, WILLIAM J.	1879–84	SCHRODER, WALTER G.
'	MILLAR, CHARLES B.	1891–96	SCOTT, GEORGE T.
3	MILNES, WILLIAM H.	1873–79	SCOTT, WALTER.
3	MORGAN, ALFRED K.	1879–82	SHARP, HERBERT.
		1887–91	SHELLEY, FREDERICK.
2	MORGAN, ETHEL M.	1890–94	SHIELDS, JOHN.
5	MULLIGAN, WALTER A.	1889–93	SHUTTLEWORTH, ALFRED.
'	MURRAY, GEORGE.		
		1895–99	SMITH, WILLIAM, J.
)	NESS, JAMES.	1879–83	SOMERSCALES, JOHN.
5	NEWBERY, FRANCIS H.	1855–59	SPARKS, JOHN.

Sessions in attendance at the College.	Name.	Sessions in attendance at the College.	Name.
1881–85	SPENCER, AUGUSTUS.	1897–01	VARLEY, ILLINGWORTH.
1897–99	SPENCER, LEONARD.	1892–95 }	VINALL, JOSEPH W. T.
1885–90	STEAD, FRED.	1896–97 }	
1883–87	STEPHENSON, CHARLES.		
1885–89	SUDDARDS, FRANK.	1895–02	WALBANK, ARTHUR L.
1864–70	SULLIVAN, MICHAEL.	1897–03	WALLACE, JAMES.
1888–00	SYMES, WILLIAM J.	1889–03	WALLIS, CHARLES A.
		1875–79	WALLIS, WALTER.
1858–63	TAYLOR, EDWARD R.	1881–85	WARD, GEORGE.
1873–78	TAYLOR, JAMES B.	1879–82	WATSON, ALFRED J.
1897–01	THEAKER, HARRY G.	1876–81	WATSON, WILLIAM P.
1874–81	THOMAS, EMMA L. (MRS.).	1871–77	WEBSTER, ALFRED G.
		1879–85	WHITE, WILLIAM F.
1862–68	THOMAS, STEPHEN.	1878–85	WHITEHEAD, ARTHUR.
1874–77	THOMPSON, FRANK.	1881–89	WILKINSON, ALFRED.
1895–00	THOMPSON, HENRY O.	1877–83	WILLIS, RICHARD H. A.
1893–96 }	THOROGOOD, STANLEY.	1877–82	WOOD, GEORGE A.
1897–98 }		1894–98	WOOD, GEORGE H.
1884–90	TRATMAN, TRACY.	1856–61	WOOLNER, HENRY (Captain).
1875–80	TROBRIDGE, GEORGE.		
1867–72	TUCKER, WILLIAM.	1888–90	WOON, ANNIE K.

Schools Associates.

FORSYTH, GORDON M. (Design).
MIDGLEY, WILLIAM C. (Sculpture and Modelling).
MORROW, EDWIN A. (Painting).
ROGERS, ARTHUR (Modelling).

List of Holders of Travelling Scholarships.

1884.

PEARCE, JOSEPH A.
ROBERTS, ELLIS W.
WARD, GEORGE.

1885.

CROMPTON, EDWARD.
MCGILL, DAVID.
TRATMAN, TRACY.

1886.

STEPHENSON, CHARLES.
MILLER, ROBERT A.
DUNLOP, JAMES M.

1887.

LEE, JOHN.
WEATHERSTONE, ALFRED C.
STEAD, FRED.

1888.

JACK, RICHARD.
ALLEN, WILLIAM H.
JAHN, ALBERT C. C.

1889.

SHELLEY, FREDERICK.
FABIAN, ERNEST.
SUDDARDS, FRANK.

1890.

KNIGHT, WILLIAM H.
SHIELDS, JOHN.
SHEPPARD, OLIVER.

1891.

PARKYN, JOHN H. P. W.
FRIPP, HENRY C. I.
MCCROSSAN, PETER.

1892.

HUGHES, JOHN.
UNWIN, WILLIAM C.
ALLISON, JOHN W.

1893.

PARKYN, JOHN H. P. W. (Honorary). } Aeq.
WHEATLEY, OLIVER. }
BURRIDGE, FREDERICK V.
BUSH, REGINALD E. J.

1894.

SIMPSON, LILIAN.
SCOTT, GEORGE.
DALTON, WILLIAM B.

1895.

MURRAY, GEORGE.
GRAY, CLAUDE W.
ALLEN, ERNEST L.

1896.

THOROGOOD, STANLEY.
STEELE, FLORENCE H.
TWISS, JANE M.

1897.

BURT, ARTHUR.
INGLES, GEORGE S.
WATSON, HARRY.

1898.

ROGERS, CHARLES H.
MAUDE, ARTHUR.
BROWN, FRANK H.

1899.

PITKETHLEY, GEORGE R.
DUXBURY, GEORGE C.
SMITH, ARCHIBALD.

1900.

BLACKLOCK, WILLIAM K
PAYNE, ARTHUR E.
THEAKER, HARRY G.

1901.

ROWBOTHAM, WALTER.
GILLICK, ERNEST.
WALLACE, JAMES.

1902.

MIDGLEY, WILLIAM.
PETTINGER, JOHN F.
MORLEY, HARRY.
FORSYTH, GORDON.

1903.

MORROW, EDWIN A.
SAMUEL, JAMES P.
GOULDEN, RICHARD R
GEORGE, WALTER S.

FORMS.

Form 882.

BOARD OF EDUCATION, SOUTH KENSINGTON,
LONDON, S.W.

(Telegraphic Address, "Instruction, London")

_____ 19

FREE ADMISSION TO MUSEUMS AND LIBRARIES.

In reply to your letter of the _____ I am directed to inform you that **the following persons only** are entitled, in accordance with the rules of the Board of Education, to the privilege of free tickets of admission to the Victoria and Albert Museum, South Kensington, including the Libraries.

(*a*) Students of the Royal College of Science, London, of the Royal College of Art, of the Royal Academy of Arts, or of the National Gallery.

(*b*) Persons recognised by the Board of Education as qualified to give instruction under the Regulations for Secondary Day Schools and Evening Schools.

(*c*) Students attending Evening Schools and Secondary Day Schools or Training Colleges.

(*d*) Teachers of Public Elementary Schools.

(*e*) Donors and Lenders to the Museums.

(*f*) Members of Learned and Artistic Societies—who must apply through the Secretaries of their respective Societies.

(*g*) Curators of Public Museums, Librarians, etc.

(*h*) Staff and Students of the Schools of Art Needlework and of Art Wood Carving.

(*i*) Persons engaged in professions or trades connected with the decorative arts, or with engineering, manufacturing or other technical pursuits; upon satisfactory evidence that they are *bonâ fide* employed in or studying for such careers, and that their means are limited.

Application for free tickets must be made by letter to the Secretary, Board of Education, South Kensington, S.W. Students of Evening Schools and Secondary Day Schools must apply through the Correspondent or Teacher of their School, and Students of Training Colleges through the Principal of their College.

Tickets can be purchased under the regulations given on the other side.*

I am,
Your obedient Servant,

To _____

See Section III. on page 3.

Form 608.
Mus.

APPLICATION FOR PERMISSION TO COPY PICTURES IN THE GALLERIES OF THE VICTORIA AND ALBERT MUSEUM, SOUTH KENSINGTON, AND BETHNAL GREEN BRANCH MUSEUM.

_____day of_____, 19

The undersigned requests permission, subject to the Regulations for Copying Pictures given at the back of this form, * to make a copy of the picture, No. _____ named_____

by_____

in the_____Museum.

(*Name*) _____
State whether Mr., Mrs., or Miss.

(*Address in full*) _____

N.B.—Permission, if granted, is available only for six weeks from the date of issue, but may be renewed.

For report of Attendant whether picture be at liberty, &c. _____*Attendant.*

Permission granted.

_____*Keeper.*

BOARD OF EDUCATION, SOUTH KENSINGTON.

Permission is granted to_____

_____

to make a copy of the Picture No. _____, named_____

_____by_____

in the _____Museum.

This permission is available for six weeks from this date and is given subject to any copyright which may be claimed, but as to which the Board of Education cannot undertake to give information or offer any opinion.

_____day of_____, 19_____.

_____*Keeper.*

N.B.—This permission does not give free admission to the Victoria and Albert Museum on Students' Days.

* See Section V. on Page 4.

Form 140.
Adm.

PHOTOGRAPHS OF
OBJECTS IN THE VICTORIA AND ALBERT MUSEUM.

The tariff for negatives and photographic proofs is as follows :—

Negatives.			Prints.					
Size.	Price.		Silver unmounted.		Platinotype or Autotype unmounted.		Extra for Mounting.	
Inches.	£	s. d.	s.	d.	s.	d.	s.	d.
4½ × 3¼		1 2	0	6	0	8	0	2
6½ × 4¾		2 7	1	0	1	4	0	3
8½ × 6½		4 7						
10 × 8		6 8						
12 × 10		10 0	1	6	2	0	0	6
15 × 12		18 9	2	6	3	0	0	6
20 × 16	1	13 4	3	0	4	0	0	6
21 × 15	1	12 10						
24 × 18	2	5 0	5	0	6	6	1	6
24 × 24	3	0 0	6	0	8	0	2	0

Lantern Slides may be obtained where suitable negatives already exist, at the following prices :—

Negatives 12 × 10 inches and under	...	...	1s. 0d.
Negatives above 12 × 10 inches	...	...	2s. 3d.

Photographs may be ordered at the Sale Stall, Victoria and Albert Museum, South Kensington, or by letter addressed to the Secretary, Board of Education, South Kensington, London, S.W.

Orders must be accompanied by a remittance of the value of the photographs required. Postage Stamps cannot be accepted for amounts of one shilling and upwards.

*** The Board of Education, whilst affording to students and others facilities for obtaining negatives or prints from existing negatives, do not hold themselves responsible for any defects, or undertake that prints shall be delivered within any definite time. The Photographer does not keep photographs in stock. Orders are executed in rotation as received, but pressure of work or bad weather may at times cause delay.

THE TARIFF FOR BROMIDE ENLARGEMENTS IS AS FOLLOWS:—

Sizes of Enlarged Prints.	Price Unmounted.		Price Mounted	
Inches.	s.	d.	s.	d.
Under 12 × 10	1	0	1	3
12 × 10	2	0	2	6
12 × 12	2	6	3	0
15 × 12	3	0	3	6
15 × 15	3	6	4	0
20 × 15	4	6	5	0
20 × 20	6	6	8	0
24 × 18	6	6	8	0
24 × 24	8	6	10	6
30 × 24	10	6	12	6
36 × 36	16	6	21	0
40 × 30	18	6	24	0
50 × 40	22	6	37	6

*** When enlargements are required where the existing negatives exceed 8½ in. × 6½ in., new reduced negatives will have to be made at an additional cost of 5s. 6d. each.

The following Classified Lists of Photographs may be obtained by personal application at the Catalogue Stall in the Victoria and Albert Museum, or by post from Messrs. Eyre and Spottiswoode, East Harding Street, Fetter Lane, E.C:

Ref. No.
275. Part I. Woodwork. 1898. 1s. 6d. [By Post 1s. 7d.]
276. Part II. Pottery and Glass. 1899. 1s. [By Post 1s. 1½d.]
277. Part III. Textile Fabrics and Lace. 1901. 1s. 6d. [By Post 1s. 7d.]
278. Part IV. Silversmiths' Work, Jewellery, Enamels, Crystals, Jade, etc. 2s. [By Post 2s. 1½d.]

Others in course of preparation.

Form 182.
Mus.

AID TO MUSEUMS APPROVED BY THE BOARD.

FORM OF APPLICATION FOR APPROVAL OF OBJECTS INTENDED FOR THE _____ MUSEUM.

To the Secretary, Board of Education, South Kensington.

SIR,

On behalf of the Committee of the above Museum we beg to apply for the approval of the Board of Education in respect of the purchase of the Objects named on the annexed list, to be acquired and exhibited upon the conditions prescribed by the Board (see page 4 of this form).

_____ *Chairman.*

_____ *Curator.*

Date _____

LIST OF OBJECTS.

No.	Description.	£	s.	d.

REGULATIONS UNDER WHICH AID IS GRANTED TO MUSEUMS TOWARDS THE PURCHASE OF OBJECTS.

1. The Grants are primarily intended to assist Provincial Museums in purchasing reproductions in plaster or by electrotype or other process, of objects illustrating architectural, ornamental, and other decorative Art.

Grants may also be made towards the purchase of original objects of similar character, but in considering applications, preference will as a rule be given to those for reproductions.

Grants may also be made towards the purchase of objects illustrative of scientific investigations.

This aid is not given in respect of appliances and examples such as are necessary to the equipment of Schools or Classes approved by the Board.

In no case will the grant be made until the objects have been approved by the Board.

2. Application for the Board's approval of the objects towards the purchase of which aid is desired must be accompanied by—

(*a*) Information of the objects in detail, together with their cost. In cases where the application to the Board has not been made prior to the acquisition of the objects, its consideration will be exceptional, and in no case will a grant be made in respect of an object after twelve months from its acquisition.

(*b*) A copy of the rules under which the Museum is administered including those for the admission of visitors and of students.

3. No grant is made towards the cost of carriage of the objects; and no object upon which aid has been granted may be sold or exchanged without the permission of the Board.

4. The grant will in no case exceed one-half the cost of the objects purchased; and it must be met by at least an equal amount raised locally by rate or voluntary contribution, exclusive of any sum received under the Local Taxation (Customs and Excise) Act, 1890.

5. When the Board's approval has been given, the grant will be paid upon the receipt of the Certificate Form 132A supported by the original vouchers with the receipts of the vendors, and copies in duplicate thereof.

6. The Museum in which the objects are exhibited must be at all times open to the inspection of the Officers of the Board.

7. A report on the Museum, containing a return of the number of persons who have visited it, must be forwarded annually to the Board as soon as possible after the 31st December.

8. All applications must be made before October 1st in each year.

Form 182a.
Mus.

GRANT IN AID OF PROVINCIAL MUSEUMS.

APPLICATION FOR PAYMENT OF GRANT IN RESPECT OF OBJECTS APPROVED BY THE BOARD.

To the Secretary, Board of Education, South Kensington.

SIR,

We the undersigned, on behalf of the Committee of the _____ Museum, request payment of the grant in aid of the purchase of the objects named on the annexed list, which were approved by the Board of Education in their letter of the _____ day of _____ 190

and we hereby certify for the information of the Board :—

That the objects have been received and deposited in the Museum, and shall be kept and exhibited in accordance with the Board's regulations.

That their whole cost has been paid, as shewn by the accompanying receipted vouchers,* and that out of the sum so paid £_____ has been provided by the Local Rates or Private Contribution.†

_____ *Chairman.*

_____ *Curator.*

*Date*_____

* *The original detailed receipted vouchers for the payments must be forwarded as well as copies of the same.*

The originals will be returned, after the copies have been compared with them.

† *Strike out whichever does not apply.*

(*This portion will be filled in by the Board.*)

Clerk in charge of the Accounts.

Please pay the sum of £_____ : _____ : _____

being _____ per cent. of total cost.

_____ *Certifying Officer.*

Payee_____

Address_____

_____ *Clerk in Charge of the Accounts.*

LIST OF OBJECTS RECEIVED.

No.	Description.	£	s.	d.

Form 605.
Mus.

CIRCULATION OF SCIENCE AND ART OBJECTS to approved Provincial Museums, Schools and Educational Exhibitions.

APPLICATION FOR A LOAN FOR A PERMANENT MUSEUM, OR TEMPORARY EXHIBITION.

The managers of the School of Science or of Art, or the Municipal or Local Authority [a] of [b] _____

apply for the loan of [c] _____

_____

_____

_____

a. Strike out the designations which do not apply.
b. Insert name of town.
c. Insert here the nature of the objects desired.

In order to enable the Board to consider the application, the following information is required.

1. The purpose of the Museum or Exhibition.

2. The class and quantity of objects contributed by the locality.

3. The purpose to which the receipts of the Museum or Exhibition (if any) are devoted.

4. The nature and situation of the building.

5. The total floor and wall space, and the amount available for the objects which may be contributed by the Board.

[*A plan and Sections of the Building, drawn to scale, to be attached.*]

6. Mode of lighting by day, whether top or side light, and mode of lighting at night.

7. Method of heating.

8. Date on which it is desired that the Board's contribution shall be sent. In the case of an Exhibition give date of opening and closing.

9 The hours of the daily opening and closing.

10. Arrangements for admission, including that of students and artizans.

11. Arrangements for the custody of the buildings and objects exhibited. Is the building patrolled?

(*a*) During the day.

(*b*) During the night.

12. Precautions

(*a*) Against fire.

(*b*) Against theft.

13. Any additional particulars which it may be considered desirable to furnish.

14. Names of the Managers of the School or Exhibition, or Members of the Municipal or Local Authority who guarantee the security and safe return of objects lent.

d. Strike out the designations which do not apply.

e. Insert name of town.

Form No. 172 or 605b will be supplied for the purpose.

I hereby undertake on behalf of the Managers of the School of Science, or of Art, or the Municipal or Local Authority d of_____ e in the event of the Board of Education contributing objects to the Museum [or Exhibition]d that the Managers [or Municipal or Local Authority]d will comply with all the conditions and regulations required by the Board of Education as stated below. I also undertake to make a return of the total number of visitors and the amount of the receipts.

*Signature*_____

Secretary of the School or of the Municipal or Local Authority.

*Date*_____

CONDITIONS AND REGULATIONS UNDER WHICH COLLECTIONS ARE CIRCULATED TO PERMANENT MUSEUMS AND TEMPORARY EXHIBITIONS.

Collections of objects of Science and Art may be lent to Museums Schools and Educational Exhibitions approved by the Board, on the following conditions:—

1. That the objects lent by the Board are supplemental to others contributed by the locality.

2. That adequate provision, previously approved by the Board, is made for their exhibition.

3. That their security and safe return are guaranteed. Valuable original objects will only be lent to Institutions in which efficient arrangements are made for their safe custody; one condition being that a sufficient number of attendants will be employed to patrol the galleries containing the loan collections, during the whole day and night.

4. That they are insured against fire and theft for the period of their absence from the Victoria and Albert Museum.

5. *Applicable only to Permanent Museums.*

   a. That the Museum consists of at least one room or gallery entirely devoted to the exhibition of objects.

   b. That the Museum is open to the public, both during the day-time and the evening, and is open *free* at least one day and one evening in each week.

   c. That the receipts, if any, are applied for the benefit of the Museum.

   d. That the Municipal or Local Authority pay, in respect of the expenses, a fixed charge of fifty shillings for each van needed to convey the objects to the Museum, and defray any local expenses; and that they provide sufficient assistance for the proper arrangement of the collection.

6. *Applicable only to Exhibitions.*

   a. That the Exhibition is open to the public, both during the day-time and the evening.

   b. That students of any local School of Art are admitted free; that arrangements are made for admission of artizans who are not students in the School at a reduced rate on certain evenings; and that in the event of the Exhibition remaining open more than three months it is free at least on one day and one evening in each week.

   c. That any surplus in the receipts is applied for the benefit of the School or Museum with which the Exhibition is connected.

   d. That the Managers, or the Municipal or Local Authority, defray the expenses of the carriage to the School or Educational Exhibition, and provide sufficient assistance for the proper arrangement of the collection.

The Board, whilst consulting the wishes of the local authorities as to the nature of the objects, reserve to themselves the absolute right of the selection.

If any object be received in a damaged state, when not in charge of an officer of the Board, a report of its condition should immediately be sent to the Board.

Glass cases, for the objects belonging to the Board which require protection, will be provided by the Board, and every object will be accompanied by a descriptive label. Such glass cases must on no account be moved except under the supervision of the officers of the Board.

With regard to Permanent Museums, the collection lent by the Board will be withdrawn at the expiration of not less than twelve months and a fresh contribution may be sent.

CIRCULATION. Form 278 Mus.

APPLICATION FOR A LOAN OF BOOKS, &c., FOR USE IN THE _____ SCHOOL OF ART.

SCHOOL NUMBER_____

We request the loan of the undermentioned books, subject to the conditions upon which books are lent to provincial schools, and we undertake to preserve them from injury, and to return them within *twelve weeks* from the date of receiving them.

On behalf of the Managers.

_____ *Correspondent.*

Dated this _____ day of _____ 190 .

(The Managers are required to defray the cost of carriage from South Kensington to the School; the charges for the return carriage will be paid by the Board.)

This form to be filled up from the Catalogue of Books, &c., issued for the information of Managers of Schools of Art. Two folio, four quarto, or eight octavo volumes may be lent at one time. The selection should include more works than are required, those most desired being placed first on the list. *If any works in the Art Library other than those in the Catalogue are required, special application must be made for them.*

This portion will be filled up at the Board's Offices.

*Circn.*_____ *Stores*_____

AUTHOR.	TITLE.	Vols.	Selected	Issued by Stores.	Returned to Stores.	Receiv'd in Circn.

CIRCULATION. Form 668. Mus.

Application for a Loan of Paintings or Drawings as Examples for Copying.

This form to be filled up from the catalogue of Oil and Water Colour Paintings, &c., issued for the information of Managers of Schools of Art. The list of selections should include more works than are required in order to prevent disappointment in cases in which paintings may have been already lent.
N.B.—Only one oil painting can be lent at a time.

This portion to be filled up at the Board's Offices.
Circ._____
Stores_____
Circ._____

ARTIST.	SUBJECT.	Reg. No.	Selected	Issued by Stores.	Returned to Stores.	Receiv'd in Circn.

We request the loan of the above examples, subject to the conditions upon which such works are lent to provincial Schools, and we undertake to preserve the examples from injury, and to return them within the required time, viz., 12 weeks from the date of receiving them.

On behalf of the Managers, _____ *Correspondent.*

_____ SCHOOL OF ART

Dated this ____ day of _____ 190

_____ SCHOOL NUMBER.

(The Managers are required to defray the cost of carriage from South Kensington to the School; the charges for the return carriage will be paid by the Board.)

CIRCULATION. **Form 159 Mus.**

APPLICATION FOR A LOAN OF EXAMPLES OF STUDENTS' WORKS.

Examples of Students' works will not be issued during the period of the Board's Examinations.

State clearly in these columns
I. The subject of each example required and
II. Whether it is to be in respect of
(*a*) Personal Local Examination, or
(*b*) Certificate or other works submitted in April for Examination at South Kensington.

This portion is to be filled up at the Board's Offices.

Circ.

I.	II.						
SUBJECT.	(*a*) Personal Local Examination.	(*b*) Certificate or works submitted for Examination at South Kensington.	Reg. No.	Selected.	Issued by Stores	Returned to Stores.	Received in Circulation.

We request the Loan of the above examples, subject to the conditions upon which such works are lent to provincial Schools, and we undertake to preserve them from injury, and to return them within the required time, viz., **two weeks** from the date of receipt.

On behalf of the Managers, _____ *Correspondent.*

_____ SCHOOL OF ART.

Dated this ____ day of _____ 190___ _____ SCHOOL NUMBER.

(The Managers are required to defray the cost of carriage from South Kensington to the School; the charges for the return carriage will be paid by the Board.)

Form 802b
S.

Memorandum as to Circulation of Collections of Apparatus and Objects for Instruction of Science Classes.

With a view to more efficient instruction of Science schools, suitable collections of apparatus have been formed specially adapted for the illustration of Science teaching. These collections are exhibited in the Victoria and Albert Museum, South Kensington, and are illustrative of the following Science subjects :—

Machine Construction.
Building Construction.
Naval Architecture.
Theoretical Mechanics.
Sound, Light, and Heat.
Magnetism and Electricity.
Inorganic Chemistry, Part I.—Elementary.
Inorganic Chemistry, Part II.—Advanced.
Geology, Part I.—Elementary.
Geology, Part II.—Advanced.
Human Physiology.
Botany.
Navigation and Nautical Astronomy.
Steam.
Physiography, Part I.—Elementary.
Physiography, Part II.—Advanced.
Agricultural Science and Rural Economy.

Duplicate sets of the above apparatus are lent, as far as available, to Science schools for short periods. The loan is made in order that teachers may have an opportunity of examining and trying the apparatus, and be enabled to make a selection for purchase of that apparatus which would be most useful for instruction.

The following are the conditions on which loans will be granted :—

1. Application must be made on Form 802. Full information as to the nature of the buildings in which the apparatus will be deposited, and as to the provision which will be made for its safe custody and protection, must be furnished. The Managers will be held responsible for the security and safe return of the objects lent.

2. No set of apparatus will be allowed to remain on loan in any Science school for a longer period than three weeks.

3. Teachers will be allowed to use the apparatus for the purpose of demonstrating before their classes; but it must not be used by the students. Any damage which the apparatus may sustain whilst in the possession of the class will have to be made good at the expense of the Managers.

4. Upon the receipt of the apparatus from the Board the Secretary of the Managers must immediately report to the Board the condition in which it is received, and specially notify any damage or injury. The Managers will be held responsible for the apparatus being safely repacked, and will be accountable for any damage which the collection may receive from the time of its receipt by them until its return to the Board.

Note.—The cost of carriage of the collection to and from will be defrayed by the Board.

REVISED TO JULY 1903. Form 1.

BOARD OF EDUCATION,
LONDON.

List of Official Publications.

*** The following publications can be purchased, either directly or through any Bookseller, from Eyre and Spottiswoode, East Harding Street, Fetter Lane, E.C., and 32, Abingdon Street, Westminster, S.W.; or, Oliver and Boyd, Edinburgh; or, E. Ponsonby, 116, Grafton Street, Dublin. Those marked with an asterisk * are also on sale at the Catalogue Stall, Victoria and Albert Museum, South Kensington, where they can be obtained, by personal application, but not by ordering through the post. With this exception none of them can be obtained from the offices of the Board.

N.B.—Applications by post to the Publishers should quote the description in full of the publications wanted, and should be accompanied by the amounts as indicated in this form. Legible signatures and full postal addresses will remove risk of failure on the part of booksellers in the execution of orders entrusted to them. The name of any parish, village, hamlet, suburb, or other locality not being a post town, is insufficient for postal purposes beyond the immediate vicinity of such place.

I. ACTS OF PARLIAMENT.

Elementary Education Act, 1870. 1*s.* 6*d.* [By post 1*s.* 7*d.*]
Ditto. 1873. 6*d.* [By post 6½*d.*]
Ditto. 1876. 1*s.* [By post 1*s.* 1*d.*]
Ditto. 1880. 1½d. [By post 2*d.*]
Education Code (1890) Act, 1890. ½*d.* [By post 1*d.*]
Elementary Education Act, 1891. 1*d.* [By post 1½*d.*]
Elementary Education (Blind and Deaf Children) Act, 1893. 1*d.* [By post 1½*d.*]
Elementary Education (School Attendance) Act, 1893. ½*d.* [By post 1*d.*]
Voluntary Schools Act, 1897. ½*d.* [By post 1*d.*]
Elementary Education Act, 1897. ½*d.* [By post 1*d.*]
Elementary School Teachers (Superannuation) Act, 1898. 1*d.* [By post 1½*d.*]
Elementary Education (School Attendance Act (1893)) Amendment Act, 1899. ½*d.* [By post 1*d.*]
Elementary Education (Defective and Epileptic Children) Act, 1899. 1*d.* [By post 1½*d.*]
Board of Education Act, 1899. 1*d.* [By post 1½*d.*]
The Education Acts, 1870–99, stitched together in pamphlet form. 1*s.* 6*d.* [By post 1*s.* 7½*d.*]
Elementary Education Act, 1900. ½*d.* [By post 1*d.*]
Education Act, 1902. 3*d.* [By post 4*d.*]
Education Acts (Elementary), 1870–1902. 1*s.* 6*d.* [By post 1*s.* 8½*d.*]
Education (London) Act, 1903. ½*d.* [By post, 1*d.*]

II. GENERAL REPORTS.

*Report of the Board of Education for the year 1902–1903. [Cd. 1763.] 5½d. [illegible] 7½d.]

I. Inspectors on Elementary Schools and
he year 1902. [Cd. 1706.] 1*s.* By post 1*s.* 3*d.*]
r Education for the year 1902. [Cd. 1738.

*Report for the year 1902 on the Museums, Colleges, and Institutions under the Administration of the Board. [Cd 1737.] 10½*d.* [By post 1*s.* 0½*d.*]

List of Public Elementary Schools and Training Colleges under the administration of the Board, 1902-1903. [Cd. 1490.] 1*s.* 5*d.* [By post 1*s.* 9*d.*]

*List of Secondary Schools, Science and Art Schools and Classes and Evening Schools, under the administration of the Board, 1902-03. [Cd. 1752.] 9½*d.* [By post 1*s.* 0½d.]

Reports from University Colleges, 1902. [Cd. 1510.] 9½*d.* [By post 1*s.* 0½*d.*]

III. ELEMENTARY EDUCATION.

(*a*) MINUTES, REGULATIONS, AND CIRCULARS.

Provisional Code of Regulations for Public, Elementary Schools and Training Colleges, 1903. [Cd. 1509.] 3*d.* [By post 4*d.*]

The Articles of the Code are referred to by number in official correspondence. With it should also be procured the following Paper.

Revised Instructions applicable to the Code of 1902. [Cd. 1120.] 4*d.* [By post 5½*d.*]

Contains the Instructions with regard to the Inspection of Schools generally; with notes on the Articles of the Code and Appendices as to—1, Specimen Schemes of Instruction; 2, The keeping of School Records (Registers and Accounts); 3, Needlework; 4, Singing; 5, Cookery and Laundry Work; 6, Facilities for Banking School Pence; 7, The Training and Instruction of Pupil Teachers; 8, Instruction of Infants; 9, Object Teaching; 10, Varied and Suitable Occupations.

Rules to be observed in Planning and Fitting up Public Elementary Schools. [Cd. 1332.] 2*d.* [By post 3*d.*]

Revised Regulations of the 21st March, 1901, as to Certificates of Age, Proficiency, and School Attendance. [Cd. 532.] 1*d.* [By post 1½*d.*]

Regulations for the Instruction and Training of Pupil Teachers and Students in Training Colleges. [Cd. 1666.] 2½*d.* [By post 3½*d.*]

Specimen Courses of Object Lessons on Common Things connected with Rural Life and Industries for all Classes in Rural Schools. 3*d.* [By post 3½*d.*]

Specimen Courses of Object Lessons and Instruction in Gardening in actual operation in Elementary Schools. 3*d.* [By post 3½*d.*]

Model Course of Physical Training for use in the upper departments of Public Elementary Schools. 3*d.* [By post 4*d.*]

Ditto. Ditto. Stoutly bound 9*d.* [By post 9*d.*]

Circulars on Reading (Nos. 407 and 408). 1*d.* [By post 1½*d.*]

These two Circulars are published as one Paper.

*Primary Drawing. Circular with illustrations and notes. [By post 6*d.*]

Specimen Courses of Instruction for Training Colleges. 4*d.* [By 4½*d.*]

Minute of 2nd April, 1894. [Cd. 7335.] ½*d.* [By post 1*d.*]

Provides for Grants on account of the education of Blind and Children.

Minute of 26th February, 1900. [Cd. 79.] 1*d.* [By post 1½*d.*]

Provides for Grants on account of the education of Defect[illegible] Epileptic Children, and prescribes conditions to be ful[illegible] Certified Schools for such Children.

Regulations as to Boarding-out Defective Children. (Statute[illegible] and Orders, 1900, No. 138.) 1*d.* [By post 1½*d.*]

Minute of 9th April, 1897. [Cd. 8420.] ½*d.* [By post 1*d.*]

Relates to the association of Schools [illegible] allotment of (*Voluntary Schools Act*[illegible]

Minute of 16th June, 1897.

Defines "Town S[illegible]

Aid Grant no[illegible]

Memorandum, dated March 1901, as to Schemes under the Voluntary Schools Act. ½*d.* [By post 1*d.*]

Elementary School Teachers Superannuation Rules, 1899. (Statutory Rules and Orders, No. 174.) 1*d.* [By post 1½*d.*]

Annuity Tables. 1*d.* [By post 1½*d.*]

A Pamphlet containing these tables, the Elementary School Teachers (Superannuation) Act, 1898, the Elementary School Teachers' Superannuation Rules, 1899, together with an Explanatory Memorandum (Circular 424), is also on sale. Price 3*d.* [By post 3½*d.*]

(*b*) STATISTICS.

Statistics of Public Elementary Schools and Training Colleges, 1901-02. [Cd. 1476.] 5*d.* [By post 6½*d.*]

(1) Grants paid to School Boards under Section 97, Elementary Education Act, 1870.
(2) School Board Accounts.
(3) List of Loans, 1901-02.

[Cd. 1276.] 1*s.* 3*d.* [By parcel post 1*s.* 6*d.*]

Return of Associations under the Voluntary Schools Act, 1897, &c., 1901-02. [Cd. 1143.] 8½*d.* [By post 11*d.*]

List of School Boards and School Attendance Committees. [Cd. 1038.] 9½*d.* [By post 1*s.* 0½*d.*]

Class List of the King's Scholarship Examination held in December, 1902. 6*d.* [By post 9*d.*]

Class List of Students at Training Colleges examined for Certificates in July, 1902. 6*d.* [By post 8*d.*]

Class List of Acting Teachers examined for Certificates in July, 1902. 6*d.* [By post 7*d.*]

(*c*) EXAMINATION PAPERS.

Questions of the King's Scholarship Examination held in December, 1902. 6*d.* [By post 7*d.*]

Questions of the Certificate Examination held in July, 1902. 6*d.* [By post 7*d.*]

Questions proposed to Pupil Teachers at the Examination held in April, 1902. 6*d.* [By post 7*d.*]

IV. HIGHER EDUCATION.

(*a*) MINUTES AND REGULATIONS.

* Regulations for Evening Schools, Technical Institutions, and Schools of Art and Art Classes, 1903-04. [Cd. 1669.] 2*d.* [By post 3*d.*]

* Regulations for Secondary Schools, 1903-04. [Cd. 1668.] 2*d.* [By post 3*d.*]

* Syllabuses and Lists of Apparatus applicable to Schools and Classes other than Elementary, 1903-04. [Cd. 1667.] 4*d.* [By post 7*d.*]

* Mathematical Tables, extracted from the Regulations. 5*s.* per hundred copies. [By post 5*s.* 8*d.*]

* † Science Syllabuses in the following subjects 6*d.* per dozen, when 12 or any even number above 12 are required. *(Those for the subjects between brackets are contained in one pamphlet, the price being the same as for a single syllabus.)* (Postage extra.) For less than a dozen the price is 1*d.* each. [By post 1½*d.* each.]

1, Practical Plane and Solid Geometry; 2, Machine Construction and Drawing; 3, Building Construction; 4, Naval Architecture; 5, Mathematics; 6, Theoretical Mechanics; [7, Applied Mechanics; [illegible]m; 5*p*, Practical Mathematics]; [8, Sound Light and Heat; [illegible]tism and Electricity]; [10, Inorganic Chemistry; 11, Organic [illegible]y]; 12, Geology; 13, Mineralogy [14, Human Physiology; [illegible]al Biology; 16, Zoology; 17, Botany]; 18, Principles of [illegible]. Metallurgy; [20, Navigation; 21, Nautical and Spherical [illegible]; 23, Physiography; 24, Agricultural Science and Rural [illegible]5, Hygiene.

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* *See Science and Art Syllabuses are included in the Vol.* :—
"D LISTS OF APPARATUS . . . ."

*Prospectus of the Whitworth Scholarships and Exhibitions, giving subjects and conditions of examinations, etc. 3*d*. [By post 3½*d*.]
*Prospectus of the Royal College of Science. 6*d*. [By post 8*d*.]
*Syllabus of the Course of Practical Instruction in Physics (Part I.) at the Royal College of Science. 1*s*. [By post 1*s*. 2*d*.]
*†Art Syllabuses in the following subjects at 6*d*. per dozen when 12 or any even number above 12 are required. *(Those for the subjects between brackets are contained in one pamphlet, the price being the same as for a single syllabus.)* (Postage extra.) For less than a dozen the price is 1*d*. each. [By post 1½*d*. each.]

Freehand Drawing of Ornament; Model Drawing; Drawing in Light and Shade from a Cast; Geometrical Drawing; Perspective; Drawing on the Blackboard; Historic Ornament; Principles of Ornament; Architecture; Architectural Design; Anatomy; Design; Memory Drawing of Plant Form; Drawing of Common Objects from Memory; [Painting Ornament and Painting from Still Life]; [Drawing from the Antique and Drawing the Antique from Memory]; Drawing from Life; Modelling from the Cast; Modelling from Life, and from the Antique; Modelling the Head from the Life; Modelling Design.

*Syllabus of Qualifications required for (1) Elementary Drawing Certificates, (2) Art Class Teacher's Certificate, and (3) Art Master's Certificates with a list of subjects of Art Instruction. 1*d*. [By post 1½*d*.]
*Prospectus of the Royal College of Art. 3*d*. [By post 4*d*.]
*Regulations relating to the Museums and Institutions. [Cd. 1218.] 6*d*. [By post 8½*d*.]

(*b*) STATISTICS.

*Annual Return made to the Board as to the application of Funds under the Local Taxation (Customs and Excise) Act, and the Technical Instruction Acts, etc., for the purposes of Science, Art, Technical and Manual Instruction in England and Wales. Price of 1902 issue, 1*s*. 1*d*. [By post 1*s*. 4*d*.]
*Return of Scholarships awarded by County Councils in England and Wales. 1896–1899. 1*s*. 4*d*. [By post 1*s*. 7*d*.]
*List of Candidates successful in Honours and list of Candidates awarded King's Prizes, at the Science Examinations 1902. 3*d*. [By post 4*d*.]
*List of Inspectors, Junior Inspectors, etc., of Secondary Branch, with Divisions, Districts, etc. 9*d*. [By post 9½*d*.]

(*c*) EXAMINATION PAPERS.

*Science Examination Papers, 1877 to 1888, 1890 to 1895, 1897 to 1899, 1901, 1902, price 6*d*. for each year. [By post 10*d*.] (The papers in each subject are not published separately.)
*Art Examination Papers, 1890 to 1895 and 1897 to 1900 and 1902, price 6*d*. for each year. [By post 8½*d*.] (The papers in each subject are not published separately.)

(*d*) MISCELLANEOUS.

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ERRATA.

PAGE.

84. For heading "Stage 2" read "Stage 1."

85. For heading "Stage 3" read "Stage 2."

,, line 10. For "Stage 3" read "Stage 2."

,, line 11. For "Stage 2" read "Stage 1."

191 and 196 and 197. The Honours Syllabuses should be interchanged.

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MEMORANDUM.

The Divisions in Science and Art Subjects other than Mathem (Subject V.), formerly described as Elementary Stage and Adva Stage are now described as Stage 1 and Stage 2, and the divisio Science Subjects, formerly known as Honours Part I. and Hon Part II., are now described as Stage 3, and Honours.

PART I.

SYLLABUSES OF SUBJECTS IN WHICH THE BOARD HOLD EXAMINATIONS.

Syllabuses of Science Subjects.

SUBJECT I.—PRACTICAL PLANE AND SOLID GEOMETRY.

This subject comprises the graphical representation of position and form, and the graphical solution of problems.

It is intended that it shall include and be confined to those principles underlying the Engineering and Physical groups of subjects which require mechanical drawing with the aid of instruments for their application.

Much lecturing is to be avoided. Students ought to be educated mainly through their own work. A large part of this work should be *quantitative*, and it is important that from the beginning, and throughout the entire course, careful draughtsmanship, and the use of properly adjusted instruments, be insisted on. All constructions should be drawn with hard and finely-sharpened pencils, and left without being inked in. Careless work, or work done with soft or blunt pencils, will receive very little credit in the examination, and may even be cancelled.

In Stage 1 the main object of the instruction will be to familiarise the student with the fundamental properties of geometrical figures and their applications, and at the same time to train him in the best use of his instruments, and in the habit of measuring his results. This object will be attained principally by the experimental verification and illustration of geometrical truths. It is not intended that the student shall follow Euclid's sequence, nor his reasoning, nor be restricted in the use of instruments by the requirements of such a system of deductive reasoning. Any method which commends itself in enforcing a geometrical truth should be employed. Thus graphical constructions may be supplemented by arithmetic when comparing quantitative results. Tracing paper will be found useful when applying the method of superposition, or plotting a locus, finding the length of a curve, etc. Squared tracing paper will sometimes prove helpful. Models should be freely used, especially in solid geometry.

Some suggestions for experiments and exercises are given later in small type. These, however, are to be regarded merely as suggestions; every teacher should develop and illustrate the subject in the way best suited to the particular circumstances in which he is placed.

Deductive reasoning and generalisations may be introduced from time to time as the student becomes fitted for them, and when any portions of the subject specially require them.

In Stages 2 and 3 and in Honours the subject will be developed in its applications to the several branches of the groups of subjects previously mentioned, and will thus tend to become technical. A sufficient choice of questions will be provided, which, including those of a general character, will enable a student who is devoting himself more particularly to any one branch to take the examination. It should be understood that it is better to confine attention to a portion of the subject, and study this thoroughly, than to range over the whole ground in a perfunctory manner.

Compulsory questions may be set at the examinations.

Students may bring tracing paper to the examination. A copy of the examination tables, p. 34, will be supplied to each candidate at the examination.

STAGE 1.

Plane Geometry.

The drawing pencil and drawing instruments.

The straight-edge, drawing board, and squares; tests of accuracy and the correction of errors.

The construction of simple geometrical figures designed to test the accuracy of the squares, and to illustrate their use in drawing parallel and perpendicular lines, and lines including angles of 15°, 30°, 45°, 60° and 75°.

Describe a circle, and by use of the tee square and set square, draw a circumscribing polygon such as a square or regular hexagon. Test whether the sides or diagonals are of equal length and whether directions of the diagonals agree with the edges of the squares.

The use of scales, especially scales decimally subdivided in which the lengths of the main divisions are respectively one inch, half inch, quarter inch, one-eighth inch, and one centimetre long. This set of scales and a protractor must be brought to the examination; also inch scales subdivided into eighths and twelfths. With what accuracy may a straight line be drawn and measured? Reasoning on the philosophy of representing things to scale is quite out of place at this stage, and is hurtful to the average student.

Students may experiment for themselves in order to get some idea of the degree of accuracy to be expected in graphical work. They can measure lines and angles, collecting and comparing results. Suitable maps may be measured to illustrate the use of scales. Tracing paper and a pricker may be used with advantage in measuring the length of a road or river.

The construction and measurement of angles from 0° to 360° in degrees and radians, by the use of a protractor, and a scale or table of chords. Limits of error in setting off and measuring angles.

Compare the magnitude of an angle as measured by a protractor and by a table of chords, noting discrepancies. Plot an angle by one method and measure it by the other. By use of tracing paper and a pricker, an arc is readily measured or a given length of arc set off. In this way construct an angle of one radian, making arc = radius, and measure the number of degrees it contains. And measure the radians in a right angle, or in any angle, and verify by the tables.

The division of lines into equal parts, and into parts in given proportion, and other illustrations of the propositions of the sixth book of Euclid.

Let students try and invent for themselves expeditious ways of effecting these important constructions, such as by employing ruled tracing paper or by bringing their scales into requisition.

The drawing of parallel and perpendicular lines by the aid of compasses. The bisector of an angle and the perpendicular bisector of a line.

Verification of the more important properties of right-angled triangles. Complementary and supplementary angles.

The construction of any right-angled triangle having given (*a*) two sides, (*b*) the hypotenuse and one side, (*c*) the hypotenuse and an adjacent angle, (*d*) one side and the adjacent acute angle, (*e*) one side and the opposite angle.

If possible, some simple apparatus or arrangement should be provided by means of which the student can find the actual height or distance of an inaccessible object from his own observation, and the plotting or solving of right-angled triangles.

The meanings of the sine, cosine, and tangent of an angle. Determination of these ratios for any angle by construction, measurement, and arithmetic. Setting out angles from tables of sines, cosines, and tangents. Solving right angled triangles by calculation, using the tables of sines, cosines, and tangents.

Every student should make these constructions carefully, results being compared with one another and with the tables.

The fundamental properties of triangles verified and illustrated by drawing. The construction of any triangle having given three independent elements. Equilateral and isosceles triangles. Similar triangles. Triangles solved by being split up into right angled triangles.

Some useful illustrations and applications of similar triangles are afforded by problems dealing with lines which intersect in points out of reach.

The construction of rectangles, parallelograms, and quadrilaterals from adequate data as to sides, angles, and diagonals.

In some cases it might be desirable to arrange for students supplied with a measuring tape to apply their geometry to some elementary surveying, such as measuring and plotting the plan of a room, or a figure drawn on it to a large scale, or a piece of ground, or by setting out a tennis court, etc. Students of teachers who use a sextant have great advantages.

Illustrations of the propositions relating to the areas of squares, rectangles, parallelograms, triangles, and quadrilaterals. The length of the circumference and the area of a circle determined experimentally.

The subject would become more real to a student if he were to find the area of some actus surface from his own measurements.

The location of points by rectangular co-ordinates.

Verification and illustrations of propositions relating to circles. Applications to such problems as the following :—

To find the centre of a given circle.

To draw the tangent to a circle at any given point on the circumference. To find the point of contact of any tangent or of two circles which touch each other.

Draw two circles, or a line and circle, to touch ; guess the point of contact ; do this several times, and in each case find the actual point of contact by construction, so as to show that the guess is unreliable.

To describe a circle to pass through three points or to touch three lines.

To describe a circle of *given radius*, (*a*) to touch a given line or circle at a given point ; (*b*) to pass through two points ; (*c*) to pass through one point and to touch a line or circle ; (*d*) to touch two lines, a line and circle, or two circles.

Here a useful variation of ordinary processes may be introduced by the employment of tracing paper.

Problems requiring a knowledge of the properties of the angles in a semicircle or in any segment of a circle, and the relations which these angles bear to the angles between the chord and the tangent at one extremity and to the angles at the centre of the circle.

Insert two pins in the drawing paper. Let a set-square, with two of its edges always in contact with the pins, be moved into successive positions, and in each case draw lines along the edges. Note the path traced by the corner of the square. Do this for angles of 90°, 60°, 45°, and 30°. Observe what happens as the corner of the square approaches its limiting position coinciding with one of the pins. Tracing paper may be used instead of a set-square.

Simple examples of geometrical loci, tracing paper being employed whenever convenient.

Miscellaneous simple problems and applications of geometrical principles.

Some useful problems may be introduced to be solved by the help of loci or by successive approximations.

Vectors.—The distinction between *scalar* and *vector* quantities. The representation of a vector quantity—(*a*) graphically, by the directed segment of a line ; (*b*) numerically, by the statement of a magnitude and an angle.

Thus a vector **A** may be defined by the expression $A\alpha$, as $26\angle 35°$ where A is its magnitude, and α its direction measured anti-clockwise from some fixed direction.

Addition of vectors. The vector triangle and the vector polygon. Vector summation applied to linear positions, displacements and velocities ; verification by drawing that the result is the same in whatever sequence the vectors are added. Rectangular components of a vector, with illustrations. The parallelogram of vectors.

In all cases numerical results should be measured from the constructions.

Vector subtraction applied to relative positions, displacements and velocities.

Vector summation applied to forces acting at a point. Experimental verification of the triangle and polygon of forces by means of cords, pulleys, and weights, and graphical construction.

Every student should have an opportunity of actually making these experiments himself, and not of merely seeing the teacher or someone else make them.

Opportunities of introducing and explaining the nomenclature of the subject will occur from time to time during the above course in plane geometry.

Solid Geometry.

The position of a point in space defined by three rectangular co-ordinates, and represented on paper (*a*) by the three projections on the planes of reference, (*b*) by a plan and elevation, (*c*) by a figured plan. Distances of the point from the axes, the origin, or the "xy" line.

The student should be directed how to cut and fold his drawing paper, so as to bring the vertical planes of reference or projection into their actual upright positions.

A straight line defined and represented by two points as above. Length of line ; inclination to horizontal plane ; traces of line.

A plane defined by the lengths of its intercepts on three rectangular axes, and exhibited graphically (*a*) by its traces on the three co-ordinate planes, (*b*) by the horizontal and a vertical trace, (*c*) by a scale of slope. Inclination of plane to horizontal plane. Points and lines lying in plane. Rabattement of plane and of any contained figures.

Again, let the student make models to illustrate these problems, by cutting and folding his drawing paper, and thus bringing the plan and elevations into their true relative positions in space.

The cube, prism, and pyramid. Plans and elevations in simple. Sections by horizontal, vertical and inclined planes. Simple developments. Projections of the triangle and square when situated with one edge in the horizontal plane. Alteration of the ground line.

A student might build up models in paper, of the cube, prism, and pyramid, from their developments.

Metric projection, applying the principle that *parallel lines project into parallel lines, all to the same scale.*

Simple applications of the preceding problems in Solid Geometry requiring quantitative measurements.

The selection of useful applications will be influenced by the class of students under instruction. Some may be interested in Machine Construction, others in Building Construction, etc.

In this course of solid geometry, opportunities will occur of explaining the terms in common use, and what is meant by projection, by the angle between a line and a plane, and the angle between two planes, etc.

It would be an advantage if there were one or two fairly large models of lines and planes, in combination, lengths and angles connected with which could be actually measured by the student, using a rule, square, and templets, etc. The models themselves could then be sketched and measured and represented in projection, and the same lengths and angles found by the methods of Solid Geometry and compared with the previous values.

STAGE 2.

The following portions of the subject are added to those of Stage 1 :—

Plane Geometry.

The construction of scales. The determination of third and fourth proportionals.

The location of points by rectangular and radial co-ordinates, and by triangulation. The construction of any polygon from adequate data. Similar figures. Enlarging and reducing figures by radial projection and by the method of squares.

Verification of the propositions of Euclid III., 34, 35, 36. Applications, including constructions for finding a mean proportional.

Regular polygons. Figures inscribed in and circumscribing other figures, with applications to simple geometrical patterns, such as window tracery. This is intended more particularly for students taking building construction.

To construct an ellipse having given the axes, or one axis and the foci.

Constructions relating to simple harmonic motions or simple vibrations. What is meant by *periodic time, frequency, amplitude, phase, epoch, representative crank, advance, lag, lead.* Interpretation of the expression $x = a \sin (qt + \alpha)$ or $= a \sin (\theta + \alpha)$. Plotting the curve of sines from given data.

Vectors.—Meaning of the symbols +, −, =, when applied to vectors. Meaning of such expressions as $\mathbf{A} = \mathbf{A}_\alpha = 21_{55°}$, $\mathbf{A} + \mathbf{B}$, $\mathbf{A} - \mathbf{B}$. $A\alpha + B\beta - C\gamma$, $2{\cdot}4_{30°} + 1{\cdot}7_{120°} - 3{\cdot}5_{271°} = A\alpha = \mathbf{A}$. Verification by drawing of the bracket law as expressed by the equation $\mathbf{A} - (\mathbf{B} - \mathbf{C}) = \mathbf{A} - \mathbf{B} + \mathbf{C}$. Meaning of the scalar product of two vectors, with illustrations.

Force in a plane defined by the statement of a length, a magnitude, and an angle.

Let OX be a fixed line in the plane, O a fixed point in OX. Let the line of any force **A** (magnitude A) cut OX in I. Let a be the length of the intercept OI. Let α be the angle, measured anti-clockwise, which the force, supposed to act outwards from I, makes with OX. Then $\mathbf{A} = {}_a\mathrm{A}_\alpha$ defines the force.

MOMENTUM AND CHANGE OF MOMENTUM.

The link polygon. Experimental illustration by means of pulleys, cords, and weights; verification by drawing of the relations which exist between the weights, the form taken by the cord, and the tensions in the segments of the cord. Conditions of equilibrium of a set of forces in one plane (the force polygon and the link polygon must be closed). Applications.

Moments of forces. Couples. Experimental verification of the principle of moments.

Solid Geometry.

General problems on lines and planes, with applications. Their intersections; the angles between them; parallel and perpendicular lines and planes. Auxiliary plans and elevations.

Problems on trihedral angles and spherical triangles, with applications.

The regular tetrahedron and octahedron, the sphere, the right circular cylinder and cone. Plans, elevations, and sections of these solids singly or in combination. Interpenetrations and developments.

STAGE 3.

Candidates must have an intimate acquaintance with the portions of the subject enumerated in Stages 1 and 2. Questions in the following subjects will also be set:—

Plane Geometry.

Cycloidal and trochoidal curves; the involute of the circle; tangent normal, and circle of curvature at any point. Envelopes. Setting out the forms of wheel teeth.

The Archimedean and Logarithmic spirals. The Ionic volute. The setting out of the profiles of cams for mechanisms in which a given motion is required to be obtained.

Additional examples of simple vibration. Easy problems relating to the motion of the slide valve of a steam engine. To compound two simple vibrations of the same period and in parallel directions by the vector addition of their representative cranks. Applications to electrical problems and the motions of machines. The locus of a point whose motion consists of two simple vibrations of the same or different periods in directions inclined to one another.

Plane motions in mechanisms. Instantaneous centre of rotation. Diagrams of velocity and acceleration. Degrees of freedom in plane motions.

Vectors. Further applications of the link polygon. Determination of centre of gravity, moment of inertia, and radius of gyration. Uni-planar forces resolved along three given lines. Form of equilibrium of flexible cord or suspension chain under given conditions of loading. Bending moments and shearing forces in beams transversely loaded.

Solid Geometry.

General problems on the line and plane.

The geometrical solids previously enumerated, and solids of revolution of any form. Their projections and sections in various positions and in contact. Simple examples of tangent planes to them. Their inter-penetrations. Developments of their surfaces (when possible), with applications to sheet metal work. Simple cases of their cast shadows, the rays of light being parallel. The perspective projection of these solids in various positions and of simple buildings or other objects. Stereographic projection. The use of contours in problems relating to irregularly curved surfaces, such as those of earthworks, ships, etc.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.). Questions will be set in the following subjects, in addition to those previously indicated:—

Problems relating to the paths, velocities, and accelerations, linear and angular, that occur in the parts of machines such as steam engines, turbines, centrifugal pumps, etc. Straining actions due to such motions. Balancing of machines.

Complex motions in machines analysed and expressed in Fourier series. Special cases, such as valve gears, in which the motion consists approximately of a fundamental simple vibration with a small superposed octave. Diagrams for such cases. Analogous problems in electrical work. Superposed simple harmonic motion of nearly equal periods. The tides. Beats.

Problems on the general case of the motion of a body in space. Degrees of freedom.

Problems on the general case of a system of forces in space. Reduction to two perpendicular forces, and to a single force along the central axis, together with the minimum couple. Braced frames in three dimensions.

Simple cases of equipotential lines and surfaces, and of lines of force.

Diagrams of maximum shearing force and bending movement, due to travelling loads. Deflection curves of beams. Problems on continuous beams solved graphically.

Line of resistance in arches and masonry structures. Diagrams of bending moment, thrust, and shear in metal and masonry arches. Fuller's diagram.

The projections of helical surfaces, including screw threads, spiral springs, and propeller blades.

The nature of the curvature of any surface. Euler's Theorem. The ellipsoid. The hyperboloid of revolution and skew bevel wheels. Other quadric surfaces.

Approximate constructions for sheet metal work for surfaces not developable.

SUBJECT II.—MACHINE CONSTRUCTION AND DRAWING.

In this subject the candidate must have a knowledge of the forms of the commoner parts of machines, obtained by drawing from sketches and models, and especially by examining, sketching, measuring and drawing actual examples of such details or of complete machines, to be followed later by practice in design more or less original. The uses of the various devices should be explained to the student.

This subject also includes a knowledge of the physical characteristics of the materials used in machine construction, the various workshop processes employed in giving the materials the required shape and size, the straining actions to which they are exposed, and the methods of estimating the dimensions necessary to withstand those straining actions.

The usual Drawing Office procedure is to keep drawings in pencil, to make tracings in ink, and to photograph these tracings. It is easy to alter the pencil drawing and take new tracings. Students will, therefore, in their classes make only pencil drawings on white paper, and in the examination they will be required, as part of the work, to make an ink tracing of a portion of a drawing, the lines being very uniform, with no visible discontinuities where straight lines and arcs of circles touch or proceed from one another. (Candidates must supply their own Indian ink.) In some offices, it is the practice to have all lines in a tracing fairly thick and of exactly the same thickness. In other offices, lines of two, and only two thicknesses are used in the same tracing. In no case ought very thin lines to be employed. It is quite easy to get beginners into the habit of producing tracings such as would be respected by workmen in the shops.

All students should be provided for class work with scales of 1", $\frac{1}{2}$", $\frac{1}{4}$", $\frac{1}{8}$", and $\frac{3}{4}$", $\frac{1}{16}$", $\frac{1}{32}$", $\frac{1}{12}$", subdivided into *eighths*, and candidates should bring these scales to the examination.

A copy of the examination tables, page 34, will be supplied to candidates in Stage 3 and Honours to assist them in calculation. Slide Rules may be used by candidates in all the stages.

Compulsory questions may be set at the examination.

In future the Subject will be divided into Stages 1, 2, 3, and Honours.

STAGE 1.

The candidate will make an inked tracing of a given simple example, to show that he can execute neat lining. He will also be required to draw in simple or orthographic projection neatly in pencil to a given scale, two or more views (sectional or outside), of a simple portion of a machine in common use. The dimensioned sketches from which the drawings are to be produced will be given. They will in general be incomplete, and be drawn purposely somewhat out of proportion, and the candidate will be required to set off, correctly to scale, dimensions, some of which are given on the view he is drawing, the remainder being obtained from the other views. He will be expected to add parts which are omitted from some of the sketches but shown in shape and size in others. He will further be expected to draw from his own knowledge the simpler fastenings which are suitable for connecting together the parts which are the subject of the example, and, in sectional views, to draw lines neatly by freehand to indicate parts cut by the planes of section, taking care to slope the lines on all the parts of the same piece in the same direction, and of contiguous pieces in directions or characters which differ from one another. An additional new view (outside or sectional), which is not shown in the sketches may be required to be drawn.

In some cases the several parts of the example may be shown detached from one another, and the candidate will be required to draw them assembled as when in use. In other cases the information may be conveyed by means of dimensioned pictorial views, or otherwise, the candidate being required to make ordinary working drawings, inserting the dimensions.

The various views required must be placed in position so as to project from one another. No credit whatever will be given unless the candidate shows that he appreciates the fact that he is producing a representation of a solid piece of machinery and not merely copying a sketch.

It is desirable that centre lines should be shown distinctly, and the parts of other lines continued too far, and not needed in the finished drawing, should be rubbed out.

In addition to the tracing and scale drawing, the candidate will show his knowledge of machine construction by making freehand sketches or giving brief descriptions of simple machine parts. For this purpose squared paper will be provided at the examination. Students should get accustomed to the use of this kind of paper when making their dimensioned sketches of the machine details which are provided for their use in class.

The following list will give some idea of the scope of the examination; candidates are not expected to have *drawn* all these details, but they are expected to examine things intelligently when they see them.

FASTENINGS.—Bolts and nuts, setscrews, studs, nut-locks. Rivets and simple riveted joints. Keys. Cotters. Pins.

MILL-WORK.—Pedestals, hangers, brackets, wall-boxes, footsteps. Shafts and couplings. Belt pulleys and belts. Spur and bevel gearing; form of pitch surfaces; drawing of wheels in section.

ENGINE AND BOILER WORK.—Piston and rod. Crosshead and slide. Connecting rod. Crank and crank-shaft. Slide valve and rod. Eccentric and rod. Cylinder with covers and stuffing boxes.

Construction of boiler shell; use of stays. Pipes and pipe joints. Stop valve.

HYDRAULIC WORK.—Pipes and pipe joints. Use of cup leather. Gland and stuffing box. Stop valve. Force pump.

BRIDGE AND ROOF WORK IN IRON AND STEEL.—Forms of rolled sections in iron and steel. Built up ties, struts and girders. Simple joints.

ELECTRIC GENERATORS AND MOTORS.—Simple details.

WORKSHOP TOOLS.—Use of the hammer and chisel, file, surface plate and scribing block. Screwing tackle. The lathe, drilling machine, planing machine, slotting machine and shaping machine.

PHYSICAL CHARACTERISTICS OF THE COMMON MATERIALS USED IN MACHINE CONSTRUCTION.—Elementary information as to the relative strength, durability under wear, resistance to corrosion, and capability of being cast or forged of iron, steel, brass, and copper.

In Stage 1 the questions and examples set will be of a very elementary character, and will relate only to such details of machines as are very commonly met with. A considerable choice will be given. Candidates will be assumed to have some knowledge of the processes carried out in the workshop where machines are made.

STAGE 2.

Will include all that has been detailed for Stage 1.

The example to be drawn to scale in the examination will be a piece of machinery of more complicated construction, requiring the candidate to possess more capability of reading drawings; and the greater part of the drawing required will consist of views not shown, but which will have to be deduced from information given in other views. A greater facility of execution will be expected to be shown by a larger quantity of tracing and drawing of a better finish than for Stage 1. And in answering the questions, a more thorough knowledge of machine construction and better hand sketching will be required. As in Stage 1, a considerable choice will be given.

The following list is added to that of Stage 1:—

Ordinary proportions of rivets and riveted joints in boiler, bridge, and roof work; of nuts and bolt-heads; and of pins, keys, and cotters. Forms of Whitworth and other screw threads.

Bearings constructed with complete provision against wear in any direction. Swivel bearings. High-speed bearings. Thrust bearings. Ball bearings. Provision against axial and lateral wear in footstep bearings. Bearings which work under water. Lubrication of bearings.

Construction of wheels and pulleys in parts. Disengaging clutches. Use of guide pulleys. Rope gearing. Chain gearing. Ordinary proportions of wheels and wheel teeth. Fixings for carrying shafts connected by gearing. Simple forms of cams and ratchets.

Various forms of pistons and piston packings. Metallic packings for stuffing boxes. Various forms of connecting rod ends. Piston valves. Expansion or cut-off valves. The common boiler fittings. Use of bridge and girder stays in boilers. Various forms of hydraulic valves. The centrifugal pump. The inward flow or Thomson turbine. Inward and outward flow turbines.

Simple details of construction of railway girders. Connection of cross girders to main girders. Building up of platform. Details of simple roofs in iron and steel. Details of electric generators and motors.

STAGE 3.

In addition to the subjects previously enumerated, the candidate may be examined in the following:—

He should be able to make simple calculations relating to the strength and durability of various machine parts. In the example to be drawn he will require to exhibit some facility in original design. His judgment as to suitable scantlings and proportions of details should have been trained by his practical experience in the workshop. He must have that kind of knowledge of the properties of materials and of workshop processes which is necessary in machine design.

Strengths and proportions of bolts and screws, tie-rods, ropes, belts and chains. Strengths and proportions of rivets and riveted joints, and of pins, keys, and cotters. Strength of shafts; horse power transmitted. Strengths of levers, beams and girders; of pipes, cylinders and boilers.

Bearing pressures on journals and pins in millwright and engine work. Pressures on slides and thrust bearings. Forced lubrication.

The design of cycloidal and involute wheel teeth for spur and bevel gearing. Strength of wheel teeth.

Details of gas and petrol engines.

Electric generators and other dynamo machines and motors; motor generators and rotary convertors.

Use of the milling machine; conditions suitable for its application. Foundry work; moulding and casting.

Physical properties of such materials as wood, leather and india-rubber, so far as these are useful in machinery.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.)

The examination in Honours is two-fold. A paper of questions will be set at the Evening Science Examinations, and those candidates who answer the questions in a sufficiently satisfactory way will be required to undergo a practical examination at South Kensington at a subsequent date. Candidates will be required to execute a drawing, or design a portion of some machine, from given data. In this part of the examination the candidate will in general be allowed the free use of text and note books, so that he may to a large extent be working under conditions similar to those which obtain in an engineer's drawing office.

Candidates must themselves provide drawing instruments and all necessary materials including indian ink and water colours, except drawing paper and drawing boards, which will be supplied by the Board of Education.

No candidate can be classed in Honours who is not successful in the practical examination.

The standard of examination for Honours is much higher than that for Stages 1, 2, and 3. The candidate should be expert in some particular branch of machine design, and have a good general knowledge of the subject as previously specified. Questions will be set at the discretion of the examiners, requiring a knowledge of modern developments of machines and

workshop practice, and involving calculations relating to compound straining actions, rigidity of parts, and vibration. Honours will not be awarded unless a candidate shows that he has made machine design the subject of prolonged and careful study.

MEMORANDUM UPON THE PREPARATION OF DRAWINGS BY STUDENTS.

In Engineering drawings (either in (Art) Subject 1*b*, from the flat, or in (Art) Subjects 23*g* and 23*h*, from measurement or designs) shading is seldom important; even colouring is not very important in drawings of machinery. An elevation or any projection which shows merely the outside appearance of an engineering object is seldom of much value in comparison with a section. Students must endeavour to produce working drawings which would be respected in actual engineering drawing-offices and workshops, and for this purpose it is necessary to pay particular attention to *lining*.

A beginner should learn the use of his instruments in tracing. He ought to take great pains with his lines, so that they shall all be of the same thickness, and so that the eye cannot detect the point of junction between one arc of a circle and another, or a straight line.

He ought not to be encouraged to submit for examination inked copies of drawings on white paper, but rather of very perfect tracings. Lines ought to be fairly thick.

A design or drawing from measurement ought to be drawn first on white paper with hard pencil in the ordinary way; the lines which are so often inked in ought only to be firmly drawn in softer pencil, the superfluous pencil lines being rubbed out; a very perfect tracing ought now to be made in ink, so that it could be repeatedly photographed for distribution to workmen and others. The student ought to send in his pencil drawing, his tracing, and, if possible, one photographic print on blue paper. If after making one tracing he finds it better to alter his pencil design, he ought to submit more than one tracing, thus giving alternative designs of certain details.

Although it is most usual to have the lines of one sheet all of the same thickness, tracings with shade lines are also in common use, and may be presented. In this case two thicknesses ought to be adhered to, except where shade lines change gradually into thinner lines.

SUBJECT III.—BUILDING CONSTRUCTION.

A larger number of questions will be set in the examination papers than the candidate will be allowed to attempt, so that he may have some range of selection of questions which bear upon branches to which he has given special attention.

A student of this subject must be a draughtsman. He should be able to show definitely by drawings what he intends to have carried out, and he should be able, with readiness, to explain details of construction by drawings and sketches. In the several stages he will be expected to show proficiency both in finished drawing and what may be called descriptive and explanatory drawing. He should know the most usual methods of multiplying drawings and copies of quantities as practised in architects' and builders' offices. He should practise sketching approximately to scale, and paper ruled in faint squares is recommended for this purpose. It is to be noted, however, that the subject of examination is Building Construction, and not drawing in the abstract. Certain of the questions set will require written answers only; for others, sketches to scale, on squared paper or otherwise, may suffice. The knowledge of drawing assumed includes the use of the usual drawing instruments, scales, various ways of laying down angles, applied projection (isometrical included), and perspective. In the 1903 examination and afterwards Students will be required to make an inked tracing of a portion of a drawing, the lines being very uniform and continuous, and fairly thick such as would be useful for a blue print.

Questions may be put which will specially test the candidate's neatness and accuracy in inking in—curves and straight lines meeting curves, etc. The student is recommended to practise neat, plain lettering and figuring.

Questions will also be set to test the candidate's knowledge of the tools, plant, and appliances used in building.

Tables (*see* p. 34) will be supplied to candidates in Honours to assist them in calculation. Slide rules may be used by candidates in all the stages.

Compulsory questions may be set at the examination.

MEMORANDUM UPON THE PREPARATION OF DRAWINGS BY STUDENTS.

Drawings to scale should be prepared in such a way as to give full information and exact guidance to the workmen who may have to use them, neither more nor less. All drawings, lettering, and numerals should be neat and clear; they should not be what is called "ornamental." Either italics or engrossing letters should be adopted.

There is no difference between the purpose of descriptive drawings for buildings and of those for machines and other constructive works, but there may be some difference in office practice in their preparation.

For good work architects should in descriptive drawings follow the modern method of machine draughtsmen. This is to produce an accurate, well-finished tracing from which any number of prints may be taken. "Blue prints," showing white lines on a blue ground, are the most easily prepared, and serve most practical purposes. But prints on a white ground are specially suitable in some cases, as they can be coloured. Students should therefore in their classes make only pencil drawings on white paper.

Students of architectural construction need to practise freehand sketching. This they may do in connection with their work in class, which should largely consist of making dimensioned sketches and drawings from actual details of building construction. Little or no drawing from mere copies should be done.

STAGE 1.

The candidate should know: How a pull or a push of so many pounds may be represented in direction and magnitude by a straight line, and how three forces in one plane in equilibrium, at a point, may be represented to scale and are parallel and equal to the sides of a triangle; the weights of water and iron, and approximately of other materials used in building; the meaning of stress per square inch (or other unit of area); roughly, the safe loads for common materials; about mortars, quality of good sand, Portland cement, limes; about slates and roofing tiles, and modes of fastening; about concreting in floors, roofs, walls, &c., plain floor tiling, spacing of joists, rafters, &c.; plain carpentry and joinery, trimming joists and rafters, usual scantlings of timber, proportions of doors, windows, floors, skirtings, simple trimmings round doors and windows; elementary ventilation and warming; bonds of brickwork; varieties of rubble masonry; plain plastering; plain painting and glazing; easy plumber's work; ironwork, locks, hinges, fastenings, grates, rainwater pipes and gutters, &c.; elementary drainage, connections with sewers and cesspools.

The bulk of the questions will have to do with simple buildings—say labourers' cottages and artisans' dwellings.

Questions will be set to test the powers of direct observation of the student, and he is recommended to miss no opportunity he may have of inspecting buildings in process of construction.

STAGE 2.

The questions set in this stage shall be designed to test advanced knowledge of the subjects enumerated for Stage 1. The bulk of the questions will apply to buildings up to and inclusive of town houses of £100 valuation, country villas, ordinary shops, and medium-sized warehouses.

The student should know: How to draw diagrams of stresses for roof trusses and simple braced girders with simple gravitation loads; how trusses of wood and of iron (or steel) are put together (spans up to 40 feet); the use of rolled joists, weights and strengths of stock sizes, the bearing of beams on walls; connection of woodwork to walls; to find the bending moment at any part of a beam under any system of gravitation loading (beam supported at both ends); what is meant by moment of inertia of a cross section; Young's modulus; combinations of iron (or steel) and Portland cement concrete; concrete roofs fireproof construction; to test Portland cement; varieties of timber, sources and characteristics; well known building stones, bricks, and building materials generally; how to take rough quantities for estimating.

Questions will be set in: Excavation for foundations, sewers, &c.; timbering, piling, concreting, framing, nature of soil, &c.; damp courses; exclusion of vermin; dampness of site; connection of walls with ground, &c.; purpose made brickwork, terra-cotta, artificial stone, &c.; stone cutting, various dressings for quoins and ashlar, stone stairs, &c.: slating sizes and qualities of slate, hips, valleys, fancy slating, creasing, shelves, cisterns, sinks, &c.; advanced carpentery and joinery, panelling, stair building, &c.; asphalting, sound deadening, ventilation, hot-water supply, heating, gas and electric supply, water supply, lightning conductors, preservation of iron, timber, &c.; lead, &c., lights in wood frames and in stone opes; various kinds of glass and glazing; ranges, grates, mantels, fastenings of all kinds; furniture of doors, &c., bells; painter's work of all kinds; advanced plumber's work, soil pipes, ventilation pipes, connections with sewers, traps inspection chambers, water-closets, baths, sinks, flashings, flats, gutters, valleys, &c.; scaffolding; shoring and strutting; effects of wind and rain on buildings, &c., &c.

STAGE 3.

This Course will include buildings of all kinds and sizes. The student will be expected to show that he can practically apply principles of physics (mechanics, chemistry, etc.) in building construction. He should be able to design roof trusses and beams of every kind; to draw stress diagrams of trusses under every kind of loading; to calculate the thrust of arches and provide for every kind of stress at every part of large buildings; to understand the method of taking quantities, and he should know something of relative and approximate prices of work and materials; to explain in a rational way the mode of manufacture of important building materials—cement making, brick making, quarrying, etc.; he should be able to describe tests for every kind of important building material; he should be able to answer questions showing an intimate knowledge of all the matters enumerated for the lower grades.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.)

This Course will include questions on the history of architecture. The candidate will be required to show by sketches and drawings that he has an accurate knowledge of notable examples of architecture. It will also include the subject of specifications.

The examiner will have in mind in setting the questions the actual practice of architects in designing buildings, and in their management of assistants and clerks of works to ensure that their orders will be properly carried out, the dealing with contractors, and also the actual carrying out of works under direct management. Candidates will be asked to make sketch designs and give instructions to draughtsmen for careful scale drawings and specifications. The questions may deal with any part of the subject and with any kind of building whatever.

Those candidates whose answering of the paper is sufficiently satisfactory will be summoned to South Kensington for a practical examination This further examination will be held on one or more days—the time will not exceed seven hours each day. Candidates will be asked to design a building suitable for a definite purpose, and they shall be required to give such plans, elevations, and sections, and such details and notes for a specification, as shall be required by the examiner. An estimate of cost will also be required.

Candidates must provide T-squares, set squares, drawing instruments, ink, and colours. Drawing paper and drawing boards will be provided by the Board of Education.

No candidate can be classed in Honours who is not successful in the practical examination.

SUBJECT IV.—NAVAL ARCHITECTURE.

Tables (*see* p. 34.) will be provided, and candidates will be restricted to the use of these tables, and will not be allowed to bring with them into the examination room any other mathematical or logarithm tables. Slide Rules may be used.

Compulsory questions may be set at the examination.

STAGE 1.

I. Practical Shipbuilding.—The usual methods of forming, fixing in place, and connecting together the component parts of the structure of a steel or iron ship, including the keel; the framing, both transverse and longitudinal; the stem and sternpost; the bottom or shell plating, inner and outer; and the keelsons, side stringers, beams, pillars, deck stringers and plating, bulkheads, ceilings, and wood decks. The wood and copper sheathing of sheathed ships. The framing, planking, &c., of composite ships. The tools and appliances used in ordinary ship work.

Details of laying building blocks; construction of rudders, bilge keels, water-tight and other bulkheads, supports to engines, boilers, and shafting.

The qualities of various materials used in shipbuilding, and the tests to which they are subjected; and the precautions to be observed in working plates and angles, both hot and cold, and the effects of punching and drilling holes.

II. Drawings to a given scale from a simple sketch that will be furnished.

The examination in Practical Shipbuilding will relate essentially to Steel Ships; but one or two questions respecting the building of Composite Ships may be asked.

STAGE 2.

I. Practical Shipbuilding.—Description and hand sketches of detail fittings of ships, such as steering gear and principal auxiliary machinery, appliances used in working the ship; anchor and capstan gear; masts and fittings in connection therewith, ventilation and coaling arrangements; pumping and draining.

Precautions necessary to prevent deterioration of hull, while building and while on service.

II. Laying off.—Comprising a knowledge of the work carried on in the Mould Loft for the purpose of fairing up a set of lines, including traces of keelsons, edges of shell plating, tank margins, rib-bands, etc., and transferring the frame and other lines to the scrive board; obtaining the dimensions for ordering the shell plating, floors, and inner bottom plating; making and marking rib-bands; shearing edges of shell plating on the frames; making templates or skeleton patterns for stem, sternpost, propeller bracket forgings or castings.

III. Ship Calculations.—The fundamental conditions to be fulfilled in order that any body may float freely and at rest in still water. Definition of stable equilibrium. Computations of areas of plane curves and of the immersed volume of a ship's hull. The weight of water displaced by a given immersed volume, and its relation to the density of the water. The specific gravities of the principal materials employed in shipbuilding, and calculations of the weight of materials, and of simple parts of a ship's structure.

The use of Simpson's and other rules for finding the position of the centre of gravity of plane areas and for calculating the position of the centre of buoyancy. Graphic or geometrical methods of finding displacement and position of the centre of buoyancy. Definitions of block, prismatic, waterplane, midship area and other similar coefficients.

IV. Drawing.—A more difficult drawing will be given than for stage 1.

STAGE 3.

I. Practical Shipbuilding.—The structural arrangements necessary to resist the longitudinal and transverse stresses to which ships are liable in still water and amongst waves, and the arrangements to resist local stresses. Methods of determining the sizes of structural parts and of detail fittings. Making out midship sections to the Rules of the principal Classification Societies; flat and vertical keel, inner bottom, shell, deck, and other plating plans; framing, beam, keelson and stringer plans; details of forging and castings. Making out general and detailed arrangement plans for the various types of ship.

Determination of Form of Intersections of Surfaces.

II. Laying off.—Expanding the plating of longitudinals by the geometric or blocking up methods; expanding stern plating, rudder trunking, mast plating, obtaining the true shape of a hawse hole in the deck or shell, and similar practical problems. Constructing and fairing the form of a twin screw bossing. Laying off problems peculiar to composite ships.

III. Ship Calculations.—Curves of displacement and of tons per inch immersion; definitions of centre of flotation, centre of buoyancy, metacentre, and metacentric height; rules for calculating positions of transverse and longitudinal metacentres; metacentric diagrams, their construction and use.

Displacement sheet and arrangement of calculations made thereon.

Definitions of change of trim; moment to change trim.

Change of trim due to moving weights on board, and that due to the addition or removal of weights.

Inclining experiment to ascertain the position of centre of gravity of a vessel and the precautions taken to ensure accuracy.

Launching arrangements.

Launching diagram and curves in connection therewith.

Calculation of strength of simpler parts of ships' structures, such as plates, butt straps, and laps; spacing and strength of iron and steel rivets. Calculation of weights of parts of ships' structures, such as decks and bulkheads.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.).

Proofs of Simpson's and other rules for obtaining areas and moments.

Approximate and detailed calculations relating to the weight and position of centre of gravity of hull.

Coefficients of weight of hull and machinery for various types of ship, also coefficients of position of centre of gravity of the ship.

Calculations for strength of parts of a ship's structure such as decks, side and bottom plating.

Calculation of shearing forces and bending moments acting on a ship floating in still water, and amongst waves; curves of loads, shearing forces, and bending moments, and their relation to one another. Equivalent girder and stress on material.

Statical and dynamical stability; Atwood's and Moseley's formulæ, and methods of calculating stability based thereon. Experimental methods of obtaining stability at any angle. Use of Amsler's integrator for calculating stability. Curves of stability, their construction and uses. Cross curves of stability.

Heeling produced by wind pressure on sails.

The principles of water-tight subdivision of war and merchant ships.

Calculation of alteration of trim and metacentric height due to admission of water into a compartment.

Resistance of ships. Froude's experiments on skin friction; Froude's law of comparison for vessels at corresponding speeds.

Methods of calculating wetted surfaces.

Methods of calculating the horse power to drive a vessel at a given speed.

Definitions of slip and pitch of propeller, effective horse-power, propulsive co-efficient, and Admiralty constant, and values of the two last in typical cases.

Speed of ships on trial, methods adopted and precautions necessary to obtain accurate speed data. Progressive trials.

Calculations relating to steering of ships. Methods of determining the size of rudder heads and the stresses on rudders, balanced and unbalanced.

Fixing the dimensions of ships to fulfil given simple conditions such as speed and weight carrying; methods of making sheer draughts.

Those candidates who answer the questions in the written paper in a sufficiently satisfactory way will be required to undergo a practical examination at South Kensington. This examination will be held on consecutive days. The time allowed for work on each day will be seven hours—three hours in the morning and four hours in the afternoon.

Candidates' practical knowledge as Naval Architects will be tested by giving them practical work of the following character:—

(1) Making a set of lines to given dimensions and displacement.

(2) Making outline plans showing the general arrangement of a vessel of one of several specified types.

(3) Preparing structural midship sections or other structural sections or plans from the sheer drawing and specified scantlings.

Candidates must themselves provide all drawing instruments, moulds, battens, straight-edges, squares, &c., and all other necessaries, except drawing-boards, drawing paper, batten weights, and drawing battens and straight edges over two feet in length, which will be furnished by the Board of Education.

Neatness and accuracy in drawing will be insisted on.

No candidate will be classed in Honours who is not successful in the practical examination.

SUBJECT V.—MATHEMATICS.

This subject is divided into seven stages. The examination in stages 1, 2, 3, and 4, and Honours in Division I. is taken on one evening; and in stages 5, 6, and 7, and Honours in Division II. on another.

Compulsory questions may be set at the examination.

In any one year a student may present himself for examination on both evenings, but he may only take up one stage, or Honours, on each evening.

The above rules apply also to the day examinations, except that no examination in Honours is held at the Day Examinations

In most cases the subject of any one stage cannot be studied without a knowledge of the subjects of the preceding stages. Accordingly in any stage the questions will pre-suppose that knowledge, and may in some cases relate to the subjects of the earlier stages. The only exception of any importance is that (except in regard to Descriptive Geometry) stage 5 is independent of stage 4.

DIVISION I.

STAGE 1.

No candidate will be allowed to pass who fails to obtain marks in any two of the three sections of this stage.

N.B.—It is important that each student should bring into the examination a pair of compasses and a straight-edge.

1. ARITHMETIC.—The principles of arithmetical operations, and their application to simple questions. The fundamental rules applied to whole numbers and to vulgar and decimal fractions. Proportion. Extraction of the square and cube roots of numerical quantities. Arithmetic as applied to ordinary questions of commerce and trade, including such questions as arise out of Bills, Interest, Per-centages, Purchase and Sale of stocks and shares. Division of profit and loss. Estimates. Weights and measures. The metrical system.

2. GEOMETRY.—The properties of lines, triangles, and rectilinear figures, as far as they are treated in the 1st Book of Euclid.

   The questions in this subject will generally be given so as to bring out as far as possible the candidate's knowledge of the principles of geometry. They will not, commonly, be set in the form of Euclid, but will consist as far as may be of definitions and easy geometrical theorems which can be proved, and problems which can be solved by the application of the well-known properties of triangles, &c. Any solution, whether in the words of Euclid or not, which shows that the candidate possesses an accurate method of geometrical reasoning will be accepted; but he should use in his demonstrations no angles but such as are less than two right angles. In other words, Euclid's limitation of the magnitude of an angle should be observed in Elementary Geometry. Candidates should endeavour to draw good figures, and should as much as possible keep the demonstration on the same page with the figure.

3. ALGEBRA.—Definitions and explanations of algebraical signs and terms. Numerical substitutions. Integral indices. Addition, subtraction, multiplication, and division of algebraical expressions and fractions. Factors, greatest common measure and least common multiple. Reduction of fractional expressions. Simple equations and problems producing them.

STAGE 2.

No candidate will be allowed to pass who fails to obtain marks in any one of the three sections of this stage.

N.B.—In addition to the instruments required in Stage 1, the students should bring into the examination in this, and all other stages, a scale of equal parts and a protractor.

All the preceding subjects, with these additions :—

1. GEOMETRY.—The properties of rectangles, circles, and polygons, as far as they are treated in the 2nd, 3rd, and 4th books of Euclid.

   The remarks under the head of geometry in the first stage are applicable to the second stage. Answers to questions may be given on any system which the student may have followed, provided the reasoning be clear and accurate.

ALGEBRA.—Involution and evolution. Surds. Quadratic equations, and problems producing them. Ratio, proportion, and variation.

PLANE TRIGONOMETRY.—Definitions. Measurement of angles by degrees and radians. The trigonometrical functions, and the conversion of one into another. Use of the positive and negative signs to denote contrariety of direction. Tracing of the trigonometrical functions in magnitude and algebraic sign through the four quadrants. The arithmetical values of the trigonometrical functions of 30°, 45°, 60°, 75°, 90°, &c.

LOGARITHMS.—Definition. Multiplication, Division, Involution and Evolution by logarithms. The use of tables of logarithms of numbers, and of sines, cosines, &c., of angles. Tables of proportional parts for numbers and angles.

TRIANGLES.—Solution of all cases of right angled and oblique triangles, and proofs of the requisite formulæ. Heights and distances. Area of a triangle.

STAGE 3.

No candidate will be allowed to pass who fails to obtain marks in any one the three sections of this stage.

All the preceding subjects, with these additions :—

GEOMETRY.—Ratio and proportion with applications to geometry, as far as the subject is treated in the definitions of Euclid's 5th Book, and in his 6th Book.

The student should have accurate notions of the ratios of incommensurable as well as of commensurable magnitudes. He should be able to answer questions arising out of the subject. Correct demonstrations, whether those of Euclid or not, will be accepted.

1. ALGEBRA.—Permutations and Combinations. Progressions. Complete theory of indices. The Binomial theorem.

3. PLANE TRIGONOMETRY.

Formulæ for finding the sine, cosine, &c., of the sum and difference of two angles, and of the multiples and submultiples of an angle. Diameters of circles inscribed in and circumscribed about a given triangle. Areas of regular polygons inscribed in and circumscribed about a given circle. Area of a circle. Description and use of the vernier and of the theodolite and sextant.

STAGE 4.

SOLID GEOMETRY.—The properties of straight lines and planes; their intersections, inclinations, parallelism, perpendicularity, &c.

Trihedral and polyhedral angles. Prisms and pyramids; their definitions, plane sections, similitude, &c.; their surfaces and volumes.

Elementary properties of the sphere, and of cylinders and cones with circular bases; their plane sections, tangent planes, surfaces, and volumes.

*DESCRIPTIVE GEOMETRY.—Representation of points, straight lines, and planes, by projections and traces on two orthogonal planes. The use of auxiliary projections and rabatments. Graphic solutions of problems concerning straight lines and planes; their intersections, inclinations, &c. Problems on trihedral angles.

* Though some knowledge of descriptive geometry is desirable for candidates in this stage it is not indispensable. A sufficient number of questions will be given in the remaining subjects of examination to enable a thoroughly prepared candidate to obtain the maximum number of marks independently of descriptive geometry.

are small circles. Angles
the angles and sides
relations between the tri-
spherical triangles,
cases. Solution of
triangles. Areas of
and circumscribed
hyperbola, ellipse, and hyperbola
PAPER I. [illegible]
PAPER I. are expected
of Mathematics, and
subject which are some-
Trigonometry." Accordingly
the following subjects:—
different transformations.
theorem for any index and
Indeterminate
test of the convergence and
summation of series. Continued
Elementary Probabilities.
Theory of Equations. In
problems requiring the aid
In TRIGONOMETRY:—
principles of the
which satisfy such equations
transformations.
expression for the sine, cosine, and
Trigonometrical series and
of the logarithms of the
PAPER II.
concerning spheres, cylinders,
their intersections by straight
tangent planes, normals, &c.
Polars and polar co-ordinates
system of such co-ordinates to
the theorems of questions relative
parallelism, perpendicu-
tangents and normals. Elementary pro-
relative to the circle. Questions concerning
and the determination of circles which satisfy
The
equations of the parabola, ellipse, and
various definitions of these curves.
tangents and normals. The principal properties of
diameters, axes, foci, conjugate diameters, asymptotes, poles and
polars.
Though some knowledge of descriptive geometry is desirable for candidates in this subject, no such problem will be given. A sufficient number of questions will be given in the remaining subjects of examination to enable a thoroughly prepared candidate to obtain the maximum number of marks independently of descriptive geometry.

Discussion of the general equation of the second degree referred to oblique or to rectangular co-ordinate axes.

ELEMENTARY DIFFERENTIAL CALCULUS.—Limits. Differential co-efficients. Differentiation of simple and inverse functions, and of a function of a function of the independent variable. Successive differentiation of a function of one variable. Taylor's Theorem and Maclaurin's Theorem, with simple applications. Easy indeterminate forms. Maxima and minima values of functions of one variable. Tangents and normals of plane curves.

Particular attention should be paid to algebraical and geometrical limits. Also to exhibiting by diagrams the maxima and minima values of functions, and the tangents and normals of curves.

ELEMENTARY INTEGRAL CALCULUS.—Elementary forms of integration; rational fractions; integration by parts; integration between limits, with easy applications to areas of curves, volumes of solids of revolution, centres of Gravity, and moments of Inertia.

As above, attention should be paid to showing by means of diagrams the results obtained in these applications.

STAGE 6.

CO-ORDINATE GEOMETRY OF THREE DIMENSIONS.—Co-ordinates of a point referred to oblique or to rectangular co-ordinate axes. Direction-cosines of straight lines. Inclination of two straight lines. Locus of points whose co-ordinates satisfy a given equation, or two given equations. Equations of planes and of straight lines. Determination of their inclinations, and of the conditions of their parallelism and perpendicularity. Other questions concerning straight lines and planes. Classification and fundamental properties of surfaces of the second degree.

DIFFERENTIAL CALCULUS.—Definitions. Limits. Differential co-efficients. Differentiation of simple functions, of inverse functions. Successive differentiation of functions of one variable. Taylor's and Maclaurin's Theorems and their simpler applications. Determination of values of functions when indeterminate in form. Differentiation of a function of a function and of implicit functions. Maxima and minima of functions of one independent variable. Differentiation of functions of two or more independent variables.

Applications of the preceding to the geometry of plane curves referred to rectangular or to polar co-ordinates. Tangents, normals, sub-tangents sub-normals, asymptotes. Singular points. Contact and curvature. Tracing of curves. Differential co-efficients of arcs and areas of plane curves, and of the surfaces and volumes of solids of revolution.

INTEGRAL CALCULUS—Meaning of definite and indefinite integration. Integration of the more frequently occurring functions. Integration by parts. Rational fractions. Formulæ of reduction.

Applications as in paragraph 4 of the fifth stage, but of a somewhat more difficult character. Also, applications to the rectification of plane curves, and to the areas of surfaces of revolution. The questions may require the use of either rectangular or polar co-ordinates.

ELEMENTARY DIFFERENTIAL EQUATIONS.—Integration of differential equations of the first order and degree. Integration of linear differential equations of the second and higher orders with constant co-efficients.

STAGE 7.

DIFFERENTIAL CALCULUS.—Differentiation of functions of two or more independent variables. Lagrange's and Laplace's Theorems. Change of independent variables. Expansion of functions of more than one independent variable. Maxima and minima of such functions. Elimination of functions.

Geometrical applications of the calculus. Involutes and evolutes of plane curves. Envelopes of curves and surfaces. Tangent planes and normals to surfaces. Tangents and normal planes to tortuous curves. Differential co-efficients of the arcs of tortuous curves, as well as of the surfaces and volumes of solids.

2. INTEGRAL CALCULUS.—Double and triple integrals. Applications of the calculus to finding the areas of curved surfaces and the volumes of solids. Change of variables in a multiple integral. Definite integrals; their differentiation and simpler properties. Fourier's Theorem.

3. DIFFERENTIAL EQUATIONS.—Their nature, origin and classification. Integrable forms of differential equations of first order and degree. The methods of integrating differential equations of first order, but not of first degree. Linear differential equations. Integration of them by symbolical methods when the co-efficients are constant. Solution of linear differential equations by means of series. Singular solutions of differential equations. Total differential equations. Simultaneous differential equations. The nature and origin of partial differential equations, and their integration in the simpler cases. Functions of Legendre and Bessel.

Honours in Division II.

Some of the questions will be on the subjects of stages 5, 6, and 7, and on applications of those subjects to the elementary parts of the theory of surfaces in general, including the curvature of lines and surfaces. Other questions will relate to the elements of spherical harmonics, and of the calculus of variations.

SUBJECT V*p*.—PRACTICAL MATHEMATICS.

The following syllabus is intended to be taken by those students who have not the opportunity of going through a complete course of Mathematics. It is suggested that students taking this course should proceed directly to Division II of Pure Mathematics.

Reference ought to be made to the Summary of Lectures on Practical Mathematics published by the Board, and to the Reports of the Examiner, since 1899. Compulsory questions may be set in any of the examination papers.

The necessary Tables, *see* p. 34, will be provided, and candidates will be restricted to the use of these Tables, and will not be allowed to bring with them into the examination room any other Mathematical or Logarithm Tables. Slide rules may be used.

STAGE 1.

ARITHMETIC.—Decimals to be used from the beginning; the fallacy of retaining more figures than are justifiable in calculations involving numbers which represent observed or measured quantities. Contracted and approximate methods of multiplying and dividing numbers whereby all unnecessary figures may be omitted. Using rough checks in arithmetical work, especially with regard to the position of the decimal point.

The use of $5{\cdot}204\times10^{5}$ for 520400 and of $5{\cdot}204\times10^{-3}$ for ·005204. The meaning of a common logarithm; the use of logarithms in making calculations involving multiplication, division, involution and evolution. Calculation of numerical values from simple formulæ.

Using algebraic formulæ in working questions on ratio and variation. Calculation of percentages. Expressing shillings and pence as decimals of a pound, quarters and pounds as decimals of a hundredweight, etc., so that all problems in practice, interest, discount, etc., become mere common-sense applications of the simple rules. No candidate need expect success who makes slips in his arithmetic.

ALGEBRA.—To understand any simple formula so as to be able to use it if numerical values are given for the various quantities. Rules of Indices.

Being told in words how to deal arithmetically with a quantity, to be able to state the matter algebraically. Problems leading to easy equations in one or two unknowns. Easy transformations and simplifications of formulæ. Practice in algebraic manipulation generally. The meaning of the expression "A varies as B."

Factors of such expressions as x^2-a^2, $x^2+11x+30$, $x^2-5x-66$.

MENSURATION.—The rule for the length of the circumference of a circle. The rules for the areas of a triangle, rectangle, parallelogram, circle; areas of the surfaces of a right circular cylinder, right circular cone, sphere, circular anchor ring. The determination of the area of an irregular plane figure (1) by using Simpson's or other well-known rules for the case where a number of equidistant ordinates or widths are given, (2) by the use of squared paper whether the given ordinates or widths are equidistant or not, the "mid-ordinate rule" being used. Determination of volumes of a prism or cylinder, cone, sphere.

The determination of the volume of an irregular solid by each of the *three* methods for an irregular area, the process being first to obtain an irregular plane figure in which the varying *ordinates* or widths represent the varying *cross sections* of the solid.

Some practical methods of finding areas and volumes. Determination of weights from volumes when densities are given.

USE OF SQUARED PAPER.—The use of squared paper by merchants and others to show at a glance the rise and fall of prices, of temperature, of the tide, &c. The use of squared paper should be illustrated by the working of many kinds of exercises, but it should be pointed out that there is a general idea underlying them all. The following may be mentioned:—

Plotting of statistics of any kind whatsoever, of general or special interest. What such curves teach. Rates of increase.

Interpolation, or the finding of probable intermediate values. Probable errors of observation. Forming complete price lists by shop-keepers. Finding an average value. Areas and volumes, as explained above. The method of fixing the position of a point in a plane; the x and y and also the r and θ, co-ordinates of a point. Easy graphs. The straight line; meaning of its slope. Slope of a curve at any point in it. Easy exercises in the solution of equations. Rates of increase. Speed of a body. Corrections for errors of observation when the plotted quantities are the results of experiment.

In all the work on squared paper a student should be made to understand that an exercise is not completed until the scales and the names of the plotted quantities are clearly indicated on the paper. Also that those scales should be avoided which are obviously inconvenient. Finally, the scales should be chosen so that the plotted figure shall occupy the greater part of the sheet of paper; at any rate, the figure should not be crowded in one corner of the paper. It is not enough to show how answers may be obtained; the correct answers must themselves be given.

GEOMETRY.—It will be assumed that candidates have been following an elementary course of study such as is outlined in the Syllabus of Science Subject I.

STAGE 2.

ARITHMETIC.—Decimals to be used from the beginning; the fallacy of retaining more figures than are justifiable in calculations involving numbers which represent observed or measured quantities. Contracted and approximate methods of multiplying and dividing numbers whereby all unnecessary figures may be omitted. Using rough checks in arithmetical work, especially with regard to the position of the decimal point.

The use of $5{\cdot}204\times10^{5}$ for 520400 and of $5{\cdot}204\times10^{-3}$ for ·005204. The meaning of a common logarithm; the use of logarithms in making calculations involving multiplication, division, involution and evolution. Calculation of numerical values from all sorts of formulæ however complex.

The principle underlying the construction and method of using a common slide rule; the use of a slide rule in making calculations. Conversion of common logarithms into Napierian logarithms. The calculation of square roots by the ordinary arithmetical method. Using algebraic formulæ in working questions on ratio and variation. Simplification of fractions; calculation of percentages. Expressing shillings and pence as decimals of a pound, quarters and pounds as decimals of a hundredweight, etc., so that all problems in practice, interest, discount, etc., became mere common-sense applications of the simple rules. No candidate need expect success who makes slips in his arithmetic.

ALGEBRA.—To understand any formula so as to be able to use it if numerical values are given for the various quantities. Rules of Indices.

Being told in words how to deal arithmetically with a quantity, to be able to state the matter algebraically. Problems leading to easy equations in one or two unknowns. Easy transformations and simplifications of formulæ, and in easy cases finding any one of several quantities in a formula when the others are given. Practice in algebraic manipulation generally. The determination of the numerical values of constants in equations of known form, when particular values of the variables are given. The meaning of the expression "A varies as B."

Factors of such expressions as x^2-a^2, $x^2+11x+30$, $x^2-5x-66$.

MENSURATION.—The rule for the length of the circumference of a circle. The rules for the areas of a triangle, rectangle, parallelogram, circle; areas of the surfaces of a right circular cylinder, right circular cone, sphere, circular anchor ring. The determination of the area of an irregular plane figure (1) by using a planimeter, (2) by using Simpson's or other well-known rules for the case where a number of equidistant ordinates or widths are given, (3) by the use of squared paper whether the given ordinates or widths are equidistant or not, the "mid-ordinate rule" being used. Determination of volumes of a prism or cylinder, cone, sphere, circular anchor ring.

The determination of the volume of an irregular solid by each of the *three* methods for an irregular area, the process being first to obtain an irregular plane figure in which the varying *ordinates* or widths represent the varying *cross sections* of the solid.

Some practical methods of finding areas and volumes. Determination of weights from volumes when densities are given.

Stating a mensuration rule as an algebraic formula. In such a formula any one of the quantities may be the unknown one the others being known.

USE OF SQUARED PAPER.—The use of squared paper by merchants and others to show at a glance the rise and fall of prices, of temperature, of the tide, &c. The use of squared paper should be illustrated by the working of many kinds of exercises, but it should be pointed out that there is a general idea underlying them all. The following may be mentioned:—

Plotting of statistics of any kind whatsoever, of general or special interest. What such curves teach. Rates of increase.

Interpolation, or the finding of probable intermediate values. Probable errors of observation. Forming complete price lists by shop-keepers. The calculation of a table of logarithms. Finding an average value. Areas and volumes, as explained above. The method of fixing the position of a point in a plane; the x and y and also the r and θ, co-ordinates of a point. Plotting of functions, such as $y=ax^n$, $y=ae^{bx}$, where a, b, n, may have all sorts of values. The straight line; meaning of its slope. Slope of a curve at any point in it. Easy exercises on rates of increase of y with regard to x in the case of $y=ax^n$. Determination of maximum

and minimum values. The solution of equations. Very clear notions of what we mean by the roots of equations may be obtained by the use of squared paper. Rates of increase. Speed of a body. Determination of laws which exist between observed quantities, especially of linear laws. Corrections for errors of observation when the plotted quantities are the results of experiment.

In all the work on squared paper a student should be made to understand that an exercise is not completed until the scales and the names of the plotted quantities are clearly indicated on the paper. Also that those scales should be avoided which are obviously inconvenient. Finally, the scales should be chosen so that the plotted figure shall occupy the greater part of the sheet of paper; at any rate, the figure should not be crowded in one corner of the paper. It is not enough to show how answers may be obtained; the correct answers must themselves be given.

GEOMETRY.—Dividing lines into parts in given proportions, and other illustrations of the 6th Book of Euclid. Measurement of angles in degrees and radians. The definitions of the sine, cosine, and tangent of an angle; determination of their values by graphical methods; setting out of angles by means of a protractor or scale of chords when they are given in degrees or radians, also when the value of the sine, cosine, or tangent is given. Use of tables of sines, cosines, and tangents. The solution of a right angled triangle by calculation, and by drawing to scale. The construction of a triangle from given data; determination of the area of a triangle. The more important propositions of Euclid may be illustrated by actual drawing; if the proposition is about angles, these may be measured by means of a protractor; or if it refers to the equality of lines, areas, or ratios, lengths may be measured by a scale and the necessary calculations made arithmetically. This combination of drawing and arithmetical calculation may be freely used to *illustrate* the truth of a proposition. A good teacher will occasionally introduce demonstrative proof as well as mere measurement, but only if his pupils take pleasure in it.

The method of representing the position of a point in space by its distances from three co-ordinate planes. How the angles are measured between (1) a line and plane, (2) two planes. The angle between two lines has a meaning whether they do or do not meet. What is meant by the projection of a line or a plane figure on a plane. Plan and elevation of a line which is inclined at given angles to the co-ordinate planes. The meaning of the terms "trace of a line," "trace of a plane."

The difference between a *scalar* quantity and a *vector* quantity. Addition and subtraction of vectors.

It will be assumed that candidates have followed the above course of study in geometry. Such examination of candidates as requires the use of instruments and drawing boards is regarded as part of Stage 1 of Subject I.

In setting out the above syllabus the items have been arranged under the various branches of the subject.

It will be obvious that it is not intended that these should be studied in the order in which they appear; the teacher will arrange a mixed course such as seems to him best for the class of students with whom he has to deal. A good teacher must understand that no examination made by anyone other than himself can be framed which will properly test the result of his teaching. The examiner will try to pass all candidates who show that their knowledge is really part of their mental machinery, so that they are sure to keep applying it to all sorts of practical problems and will no more allow it to get rusty than their power to read or write or walk.

STAGE 3.

The instruction given in Stage 3 should include a revision of some of the more important portions stated in the syllabus for Stage 2. In addition, the following should be considered:—

More practice in the use of logarithms and other mathematical tables for finding numerical values from more difficult or more complicated formulæ. More attention to *method* in carrying out computations of all kinds. The use of approximate formulæ such as

$$(1 + a)^n = 1 + na \text{ when } a \text{ is small compared with 1.}$$

Rules in Arithmetic (as of compound interest, &c.) and in Mensuration, stated as algebraic formulæ. Any one of the quantities in a formula may be the unknown one.

Practice in the simplification of algebraical expressions. Solution of equations, and problems leading to equations. Resolution of a fraction into partial fractions.

TRIGONOMETRY.—Knowledge of such limits as $\sin \theta \div \theta$.

How to find the values of the sine, cosine, and tangent for angles greater than 90°.

The fundamental relation, $\sin^2\theta + \cos^2\theta = 1$.

Calculating the values of $\sin x$, $\cos x$, e^x, and $\log x$ using series.

The fundamental formulæ for the sine and cosine of the sum or difference of two angles, that is

$$\sin (A + B) = \sin A \,.\, \cos B + \cos A \,.\, \sin B$$

and the other similar ones. Formulæ derived from the above, such as those for the sum and difference of two sines or cosines, and those which connect an angle and the double angle.

The sine rule, or $\frac{\sin A}{\sin B} = \frac{a}{b}$ in triangles. Also the rule $c^2 = a^2 + b^2 - 2ab \cos C$.

The expression for the area of a triangle, having given two sides and the included angle, $\frac{1}{2} ab \sin C$.

The truth of such formulæ ought to be illustrated numerically and graphically by taking numerical values of the quantities, but the proofs are also supposed to be known to candidates.

MENSURATION.—Theorems relating to areas and volumes of surfaces and solids of revolution. Exercises on the area of a segment and sector of a circle, the area of the surface of a sphere between any two parallel planes; approximate rules for length of a circular arc.

Finding centres of gravity and moments of inertia using squared paper.

USE OF SQUARED PAPER.—The plotting of functions including such as $y = ax^n$; $y = ae^{bx}$; $y = a \sin (cx + d)$; $y = ae^{bx} \sin (cx + d)$.

Having given observed values of two varying quantities which are known to follow one or other of laws like $pv^n = c$, $y = a + bx^2$, $axy = bx + cy$, to find the probable values of the constants.

When two varying quantities are known to follow a given but somewhat complex law, to determine a simpler law which, between certain limits, will give values approximating to the correct ones.

Solving equations by the use of squared paper.

Maximum and minimum problems.

GEOMETRY.—How the position of a point in space is defined by its rectangular co-ordinates x, y, z, or by its polar co-ordinates r, θ, ϕ; the relations between x, y, z and r, θ, ϕ.

Determination of the three angles α, β, γ which a given line makes with the three co-ordinate axes; the relation

$$\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$$

Determination of the angles between a given line and each of the co-ordinate planes.

When a plane is given by its traces, to determine its inclination to each of the three co-ordinate axes and planes.

The above may be treated analytically or graphically.

Representation by its projections on the three co-ordinate planes, of a line whose position and real length are given.

Determination of the angle between two given lines; the angle between two planes whose traces are given. Represent by its projections the line of intersection of two planes whose traces are given.

Such examination of candidates as requires the use of instruments and drawing boards is regarded as part of Subject I.

VECTORS.—The scalar product and vector product of two given vectors with illustrations. Vector Algebra.

RATES AND SUMS.—Rate of increase of one quantity relatively to that of another; approximate methods of calculating a rate of increase as, for example, in the case where simultaneous values of two varying quantities have been observed experimentally, or by finding the *slope* of the curve obtained by plotting such values.

The term "differential coefficient as applied to a rate of increase; and the symbol for it, namely $\frac{dy}{dx}$, where y and x represent the two varying quantities.

Rules for finding the differential coefficient of y with respect to x, that is, $\frac{dy}{dx}$, when y and x are related in the following ways:—

$y=ax^n$; $y=ae^{bx}$; $y=\sin x$; $y=\cos x$; $y=a\sin(bx+c)$; $y=A\log(x+a)$.

The study of these functions.

Proof and use of the rules for differentiating a product of two functions or the function of a function, successive and partial differentiation. Integrating by parts and by substitution and other simple devices.

Calculation of maximum and minimum values.

Integration regarded as the inverse of differentiation, or as a process of summation; the symbols

$\int y.\,dx$ and $\int_a^b y.\,dx$; rough methods of finding an approximation to $\int_a^b y.\,dx$ when numerical values of y and x are known.

The expressions for the following integrals

$$\int ax^n\,dx; \quad \int ae^{bx}\,dx; \quad \int \frac{A}{x+a}\,dx$$

$$\int A\sin(ax+b)\,dx; \quad \int A\cos(ax+b)\,dx$$

The solution of simple differential equations.

Illustrations of the use of the calculus.

Special attention ought to be paid to graphical methods of integration, using squared paper; the construction by graphical methods of curves from a given law of slope, this law being given either by means of a curve, or a simple algebraic expression, or by means of a simple differential equati

SUBJECT VI.—THEORETICAL MECHANICS.

There are two distinct nomenclatures applicable to Subject VI. According to one, the science that investigates the action of force is called mechanics, and is divided into (*a*) statics, treating of the equilibrium of particles and bodies, (*b*) dynamics, treating of the motion of particles and bodies, (*c*) hydrostatics, (*d*) hydrodynamics, treating respectively of the rest and motion of fluids, *i.e.* liquids and gases. This nomenclature is adopted by many writers of authority, *e.g.* by Poisson. According to the other, the term dynamics takes the place of mechanics, and the division is into: (i) statics, (ii) kinetics, (iii) hydrostatics, (iv) hydrokinetics. This is a question of words only, but of course one terminology may be better than another. It is, however, to be observed that a considerable number of questions, formerly treated under the head of (*b*) dynamics, relate to motion without reference to the forces producing it. These questions form a distinct branch of pure mathematics to which the name of kinematics is now commonly given. Certain parts of kinematics come into Subject VI., but they occupy a subordinate position in it.

Subject VI. can be taken in two divisions, the first corresponding to (*a*) and (*b*) defined above, the second corresponding, with modifications, to (*c*) and (*d*). In most cases it would be best for students to take up Stage 1, or even Stages 1 and 2, of the first division, before attempting the second division. However, students take their choice, and to enable them to take up the second division as a separate subject, the syllabus of the second division contains several articles which also come into the first division.

In each division there is a Stage 1, a Stage 2, and a Stage 3. There is also an Honours Stage for both divisions combined. The distinction between the stages is much the same in the two divisions.

In Stage 1 the student is required to make himself acquainted with the axioms and the elementary propositions and formulæ of the science, as simple matters of fact, independently of their formal proof. For instance, he must know the proposition called the parallelogram of forces, as a matter of fact, and must be able to apply his knowledge; but he will not be required to prove the proposition. In like manner he will be required to know what is the metacentre of a floating body, but not to prove the formula for finding its position. In a word, he will be required to make brief exact statements, and to work out easy examples. With perhaps an occasional exception, the examples will be either arithmetical, or capable of being answered by an easy construction drawn to scale. No question involving complicated algebra or geometry will be set. The student should be able to substitute numerical values in an algebraical formula, and to solve a simple equation. He should also have accurate notions of ratios. Every student should bring to the examination a pair of compasses, a scale of equal parts, and a protractor.

In Stage 2 of either division the student will be concerned with the mathematical treatment of the principles which form the subject of Stage 1 of the same division, so far as the subject can be discussed with the aid of what is generally called elementary mathematics. He should pay particular attention to the proofs of the mechanical propositions referred to in the syllabus of the courses. Thus, he should not merely know that when a particle moves in a circle the force acting towards the centre is given by the formula $mv^2 \div r$, but he should be able to state the reasoning by which the fact is proved, and to apply his knowledge to a moderately hard example. He should not merely know the rule for finding the magnitude of the resultant pressure of a liquid on a plane area, but be able to state the proof of it.

Stage 3 of either division will be, as it were, a continuation of Stage 2, as will be plain from the detailed statement of the contents given below. In this stage it will be assumed that the student has a somewhat more advanced knowledge of pure mathematics.

In Honours it will be assumed that the student has a fair knowledge of what is commonly understood by the higher mathematics, though in drawing up the questions it will be endeavoured to exclude those which have a merely geometrical or algebraical interest.

It is of course understood that in any stage of either division questions may be asked, which fairly arise out of the contents of any previous stage. It may be added that in all stages the student should bring to the examination the drawing instruments that are necessary for Stage 1.

Compulsory questions may be set at the examination.

DIVISION I.—Solids.

STAGE 1.

1. Units of time and distance; distinction between speed and velocity; measurement of velocity, whether constant or variable; measurement of acceleration, particularly of constant acceleration; acceleration due to gravity; mass or quantity of matter, unit of mass, density, specific gravity (or specific density); momentum; measurement of force; absolute units of force, particularly the poundal or British absolute unit; distinction between the mass and the weight of a body.

2. Specification of a force. Composition of forces, particularly of two forces, whether acting along intersecting or parallel lines. Equilibrium of two or three forces. Statical couples. Moment of a force. Centre of parallel forces. Work done by a force. Units of work, foot-pound; units of power, horse-power.

3. Different states of matter. Elasticity. Resistance to (1) elongation (2) compression, (3) bending and (4) torsion.

4. Centre of gravity, and its position in simple cases. Reaction of smooth surfaces, points, and hinges. Equilibrium of a body capable of turning on a fixed point or fulcrum. Levers; the steelyard; the balance and its sensibility. Tension of a thread. Pulleys. Equilibrium of a body resting on a smooth plane, horizontal or inclined. Stable and unstable equilibrium.

5. Laws of uniformly accelerated rectilinear motion, and the formulæ embodying them, viz., $v = V + ft$, $s = Vt + \frac{1}{2} ft^2$, $v^2 = V^2 + 2fs$. Atwood's machine.

6. Composition of two velocities. Uniform motion in a circle; centrifugal force. Small oscillations of a simple pendulum, and of a compound pendulum. Convertibility of the centres of oscillation and suspension. Determination of the numerical value of the acceleration due to gravity. Force exerted by the earth on the same mass at different places.

7. Definition of energy. Distinction between potential and kinetic energy. Absolute units of work, particularly the foot-poundal. Equation of work and energy for a constant force acting on a particle.

STAGE 2.

1. Relative rest and motion. Composition of velocities. Determination of the velocity of a moving point, relatively to another moving point. Angular velocity.

2. Newton's three laws of motion, and his proof of the parallelogram of forces.

3. The composition of forces—including parallel forces and couples—acting in one plane, and the conditions of their equilibrium. Centre of parallel forces.

4. Determination of the centre of gravity in ordinary cases. Properties of the centre of gravity.

5. Friction and laws of friction ; co-efficient and angle of friction.

6. Equilibrium of simple machines when friction is not, and when it is, taken into account. Inclined plane, wedge, screw, pulleys. Equilibrium of a body resting on an axle, whether smooth or rough.

7. Virtual work. Stable and unstable equilibrium.

8. Work done by a variable force ; diagrams of work in simple cases ; the indicator diagram.

9. Rectilinear motion under the action of constant forces, particularly on smooth or rough inclined planes.

10. Motion of projectiles ; motion in a circle ; motion of a simple pendulum.

11. Impulsive forces. Direct and oblique impact of smooth spheres.

STAGE 3.

The student should be prepared to answer somewhat difficult questions in Stage 2. Also, he should study the subjects indicated in the following articles, viz. :—

1. The general theory of the composition and resolution of forces, and of the equilibrium of a rigid body. Centre of gravity. The easier questions in attractions.
2. Virtual work.
3. The elements of uniplanar kinematics.
4. Differential equations of the motion of a particle. Constrained motion of a particle, with applications to circular motion.
5. Moments and products of inertia.
6. Motion of a rigid body about a fixed axis.
7. Energy of a particle and of a rotating body.

DIVISION II.—Fluids.

STAGE 1.

The subject of Division II. cannot be understood unless the student has a preliminary acquaintance with the fundamental notions of force and motion, on which all parts of the science are based. These are given in Sections 1 and 2 of the following syllabus. He should also understand what is meant by the resultant of two or more forces, and that in the case of two or more parallel forces the resultant equals the sum of the forces. He should know what is meant by the centre of gravity of a body, some of its elementary properties, and its position in the case of such bodies as sphere, prism, cylinder, circle, parallelogram.

1. Units of time and distance ; measurement of velocity, whether constant or variable ; measurement of acceleration, particularly of constant acceleration, acceleration due to gravity ; mass or quantity of matter, unit of mass, density, specific gravity (or specific density) ; momentum ; measurement of force ; absolute units of force, particularly the poundal or British absolute unit ; distinction between the mass and the weight of a body.

2. Definition of energy ; distinction between potential and kinetic energy ; the work done by a force ; absolute units of work, particularly the foot-poundal ; equation of work and energy for a constant force acting on a particle.

3. Definition of fluid and liquid ; transmission of pressure through a fluid ; measurement of pressure at any point of a fluid ; surface of a liquid acted on by gravity, and pressure at any point within the liquid ; distinction between the whole pressure and the resultant pressure of a liquid on a given

surface; magnitude and line of action of resultant pressure in the case of a rectangular area, one edge of which is on the surface of the liquid; also in the case of a body wholly or partly immersed in a liquid.

4. Conditions of equilibrium of a floating body; definition of the metacentre; position of a metacentre in the case of a sphere, and of a cylinder with its axis vertical (the formula 4 HM. $hs = r^2$ being assumed); stability of flotation.

5. Determination of the specific gravity of insoluble solids, and of liquids, (1) by the balance, (2) by the specific gravity bottle, (3) by Nicholson's hydrometer; specific gravity of solids lighter than water by the balance; weight of a body in air and in vacuo.

6. Distinction between heat and temperature; definition of higher and lower temperature, and of equal temperatures; the mercurial thermometer, and its graduation; Fahrenheit's, the Centigrade and Réaumur's scales. Definition of absolute zero.

7. Air is a heavy elastic fluid; the barometer; pressure of air on the sides of a vessel containing it; variations in this pressure consequent on change of volume and temperature, *i.e.*, Boyle's Law and Dalton's Law, and the formula in which they are embodied, viz., VP=CT; limitation of Boyle's law; contents of the "vacuum-space" in barometers of different liquids.

8. Hydrometer of variable immersion; suction-pump; force-pump; siphon; air-pump and mercurial gauge; compressed air manometer; hydraulic press.

STAGE 2.

The demonstrations and additional subjects of Stage 2 require corresponding extensions in the preliminary part of the course, as mentioned below. But besides this the student should extend his knowledge of the centre of gravity, and learn how to find the moment of inertia in such simple cases as involve no more than finding the limiting value of $\Sigma_b^a (x^n \Delta x)$ by integration or otherwise, including the case in which $n = -1$.

1. Composition and resolution of forces acting on a body, and the general conditions of their equilibrium. Angular velocity. Uniform circular motion. Work done by a variable force.

2. Resultant pressure of a liquid on an immersed surface plane or curved. Centre of pressure in simple cases. Equilibrium of bodies floating freely or partly supported. Metacentre in simple cases (the formula HM . $V = Ak^2$ being assumed). Tension of a thin flexible cylinder or sphere under internal fluid pressure.

3. Pressure and elasticity of air; height of the homogeneous atmosphere; variations of the height due to variations of gravity and temperature; pressure of mixed gases; vapours in contact with the liquid producing them; saturation; the dew point; densities of dry and moist air. Work of gas expanding at a constant temperature.

4. Elementary notions of surface tension; rise of a liquid between two plates, and in a capillary tube.

5. Surface of a liquid in a vessel rotating steadily, under the action of gravity; pressure at any point of the liquid.

6. Velocity of a liquid issuing from a hole in the side of a vessel (Torricelli's Theorem); velocity of the descending surface of the liquid.

STAGE 3.

The student should be prepared to answer somewhat difficult questions in Stage 2. Also he should study the subjects indicated in the following articles, viz. :—

1. Pressure at any point of a fluid at rest acted on by any forces.
2. Resultant pressure of a liquid on a plane or curved surface.
3. Centre of pressure of a plane area.
4. Stability of flotation in respect of small displacements ; case in which the displacement is large.
5. Particular attention should be paid to Art. 3, Stage 2 of Division II., and extensions, *e.g.*, to the determination of Heights by the Barometer.
6. Ditto, Art. 4, with extensions.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.)

Candidates for Honours in Theoretical Mechanics should have a good knowledge of both divisions of the subject as defined in the foregoing syllabus, and of the subjects indicated in the following articles. They should have a fair knowledge of what is commonly understood by the Higher Mathematics. The course of Co-ordinate Geometry and of Differential and Integral Calculus marked out in the fifth stage of Mathematics may be looked on as a minimum.

1. Equilibrium of threads.
2. Deflection and rupture of beams.
3. Application of Art. 4, Stage 3, Division I. to the motion of a particle under the action of a central force.
4. General equations of the motion of a rigid body.
5. Motion of a rigid body in space of two dimensions.
6. The general principles of dynamics.
7. Specific heat of air at constant pressure and at constant volume. Adiabatic expansion. Elements of the kinetic theory of gases.
8. The hydrodynamical equation $\frac{1}{\rho}\cdot\frac{dp}{ds}=\mathrm{S}-v\frac{dv}{ds}$. Equation of continuity. Steady motion of fluids under the action of gravity. Bernoulli's Theorem.
9. Elementary notions of the propagation of an aërial disturbance along a straight tube ; representation by diagrams of the motion of the aërial particles constituting a wave ; explanation of the interference of two waves ; corresponding representation and explanation by means of sine functions—*e.g.*, $a\sin\left\{\frac{2\pi}{\lambda}(vt-x)+\mathrm{A}\right\}$.
10. Motion of aërial waves in a straight tube; investigation and integration of the equation $\frac{d^2z}{dt^2}=a^2\frac{d^2z}{dx^2}$; application to the velocity of sound and to the simpler cases of vibrations in tubes.

SUBJECT VII.—APPLIED MECHANICS.

It is understood that in all the stages, and particularly in the higher stages, candidates must exhibit some knowledge of the difficulty of applying academic theory to practical problems. Compulsory questions may be set in any of the examination papers. The necessary Tables, *see* p. 34, will be supplied, and candidates will be restricted to the use of these Tables, and will not be allowed to bring with them into the examination room any other Mathematical or Logarithm Tables. Slide Rules may be used.

STAGE 1.

Candidates will not be examined on their mathematical knowledge, but they are supposed to know that too many figures in an arithmetical answer are misleading; to know how to use mathematical formulæ; to have tested for themselves by drawing and measurement such laws as that about the squares of the sides of a right-angled triangle; they are supposed to know what is meant by a person who in a railway train says, "we are travelling at 30 miles an hour."

They are supposed to be learning mechanics by their own observation of machinery, and other things, and they should have such a knowledge of the action of hand and machine tools, and machinery in general use, as will show that they do observe and try to understand how the principles of mechanics and properties of materials are applied to them. It is unnecessary to give a long list of such mechanical contrivances. An intelligent examination of the ordinary tools used in a small engineering establishment is supposed.

The candidate is supposed to have the sort of knowledge which comes from elementary lectures, and from seeing, trying, and measuring in a laboratory, where wires may be stretched or twisted, or beams may be broken, and such machines as pulleys, or blocks and tackle, or screw jacks, or levers, may be tested to illustrate the effects of friction. Very simple apparatus if used by a student himself will give the sort of knowledge that is expected.

He is expected to know how squared paper is used in representing the results of experiments. Also, if he tests the pushing and pulling forces of pieces which act at a hinge, to be able to draw the triangle or polygon of forces; and generally should be able to work elementary problems in Graphical Statics; to find the resultant of forces not meeting at a point.

He must have elementary notions as to how an arch supports a load; the sort of notion obtainable by working with blocks of wood slightly curved on the faces, to represent the stones of an arch.

The use of measuring instruments, rules, callipers, micrometers, and other gauges used in workshops and mechanical laboratories. Surface plates. Measurement of energy. Calculations of work and power. Mechanical advantage, and easy examples of the effect of friction in machines. Blocks and tackle, and other lifting appliances. Screws. Hydraulic presses, cranes, pumps, &c., and simple calculations concerning them.

Communication of power by shafting, pulleys, couplings, clutches. Belt, rope, and chain driving.

The elementary principles of force and motion as applied to fly-wheels and other rotating bodies. Force of a blow. Forces producing reciprocating motion. Centrifugal force.

Properties of materials used in construction. Stone, cement, bricks, timber, glass, cast iron, wrought iron, mild and cast steel. Tempering.

What occurs in material when a push or pull is exerted. Loading an iron or copper wire till it breaks. Candidates are supposed to have loaded such a wire themselves. Tie rods and struts. Stress and strain. Strength of thin vessels like boilers.

Twisting a wire or shaft and the bending of a beam; what occurs in the material? Candidates must have a fairly clear notion of what occurs in a beam fixed at one end and loaded at the other. Exact calculation of bending moment and shearing force will not be expected, but there should be an intelligent general knowledge of what each part of a girder is intended to do. Some knowledge of the stiffness of springs is expected, such as may be obtained by observation and measurement.

Lifting and force pumps. Such a knowledge of how the pressure and velocity in fluids depend upon one another as will enable a candidate to understand the flow of fluid from orifices and suction produced by a jet.

STAGE 2.

Candidates are understood to have an advanced knowledge of the subjects of the preceding course, being able to apply elementary mathematics to any practical problem. They must possess exact notions of a "rate" (as in velocity), or of an integral (as in finding an area, or finding work done under varying force), and show that they have understood what they are in the habit of doing with curves and columns of figures in practical problems such as :—Given the values of the force on a body at equal intervals of space, and the mass ; to draw curves showing the velocity at each place and the time. For example such problems as are sometimes given on the Bull engine.

Mechanism. Conversion of motion. Velocity ratios. Instantaneous axes. Belts, ropes, chains, links. Sliding and rolling. Wheel trains. Teeth of wheels. Chain gearing. Epicyclic trains.

Calculation of hypothetical effects of friction in screws and other machines. Overhauling. A good general knowledge of the effects of friction. Rolling friction. Roller bearings.

A sounder knowledge of the elementary principles of graphical statics than is expected in the preceding Course. Finding moments of inertia of areas. Lines of resistance in arches and buttresses. Bending moment and shearing force diagrams. Fuller's rule for masonry arches.

Balancing in hydraulic and other lifts.

Slipping of a belt. Length and strength of belts. Speed cones.

Applications of the principles of the dynamics of rotating bodies as in fly-wheels.

Effect of a blow. Reciprocating motions and vibration, linear and angular ; measurement of torsional rigidity and fluid friction by torsional vibrations. Balancing of quick moving machinery.

A more intimate knowledge of the properties of materials used in construction. How they behave in testing machines. Influence of shape of section of test piece. Fatigue. Flow of metal. Initial strains. A better knowledge of stress and strain ; shear stress and strain. Pressure of water and earth. Copper and its alloys ; brass, gun metal, bronzes.

Riveted joints. Strength of vessels with thin shells under fluid pressure. What occurs in a twisted shaft or bent beam. Bending moment and shearing force. Some knowledge of practical problems on railway girders.

A general knowledge of the effects of combined bending and twisting, and bending and crushing. Struts. Metal and masonry arches. Spiral springs, carriage springs. Vibrations.

Changes of pressure and velocity along the stream lines in fluids ; in the various parts of a centrifugal pump or turbine. Gauge notches for measuring water. Thomson's jet pump. Friction in pipes. Hydraulic propulsion. The effects of friction in pipes and passages of hydraulic machinery.

Candidates are not expected to be able to prove mathematically the more complex rules, for example those adopted in working practical problems on combined bending and twisting, but they must be able intelligently to apply the rules, and they must understand the principles underlying the rules.

STAGE 3.

Candidates must possess a more advanced knowledge of the subjects of Stages 1 and 2.

The results of experiments on friction at journals and in pipes, &c., conveying fluids.

In graphical statics they are expected to be able to use their descriptive geometry to find the resultants of forces not in one plane, or the forces in part of a structure not in one plane. The principal moments of inertia of an area. Theory of masonry and metal arches with three, two, or no hinges. Effect of temperature on a hinged structure.

Mechanism. The kinematics and kinetics of machines. Linkages in general. Wheel teeth. Worm wheel teeth. Sliding and rolling contact. Mechanical integrators. Rolling cylinders and cones and the most general motions of bodies. Slipping of belts. Centrifugal force in belts and rims of pulleys.

Effect of a blow. Stoppage of water in a pipe. Vibration and the effect of friction in vibration. Velocity and acceleration, diagrams of parts of mechanisms. The balancing of machinery.

Long pump rod. Thick cylinders. Bending moment and strength and deflection of beams in general. Beams fixed at the ends. Continuous beams. Shear stress in beams. Combined bending and torsion; bending and thrust. Struts. A coupling rod as a strut and beam.

Spiral springs. Springs of any shape subjected to bending.

Whirling fluid. Centrifugal pumps. Fans and turbines. Hydraulic propulsion. The change in pressure and velocity along and across stream lines in water or air. "The rotation" in a fluid.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.)

A knowledge of the best current literature on the subject.

The application of graphical and algebraic calculation to the more difficult problems in Applied Mechanics. Most of these problems are stated under the first three Stages. Particular mention may be made of:—

Recent work on helical teeth and other mechanism.

Recent investigations on lubrication and friction in pipes.

The results of the most recent experiments on properties of materials.

Forces not in one plane. Hinged and riveted structures with any kind of loading.

Vibration in structures. Balancing of machinery. Twisting vibrations in shafts.

Stability of shafts under centrifugal force, bending, thrust, and torsion. Long columns. Struts laterally loaded. The strength of a link such as a connecting rod at any speed of the engine. Deflection due to shear strain in beams.

Candidates will be expected to know enough of the mathematical theory of elasticity to be able to vindicate engineer's methods of calculation in shaft and beam problems; thick cylinders; rotating disc; local effects of loading.

EXAMINATION TABLES.

USEFUL CONSTANTS.

1 Inch = 25·40 millimetres.

1 Gallon = ·1604 cubic foot = 10 lb. of water at 62 F.

1 Knot = 6080 feet per hour.

Weight of 1 lb. in London = 445,000 dynes.

One pound avoirdupois = 7000 grains = 453·6 grammes.

1 Cubic foot of water weighs 62·3 lb.

1 Cubic foot of air at 0° C. and 1 atmosphere, weighs ·0807 lb.

1 Cubic foot of Hydrogen at 0° C. and 1 atmosphere, weighs ·00559

1 Foot-pound = $1·3562 \times 10^7$ ergs.

1 Horse-power-hour = 33000 × 60 foot-pounds.

1 Electrical unit = 1000 watt-hours.

Joule's Equivalent to suit Regnault's H, is { 774 ft.-lb. = 1 Fah. uni
1393 ft.-lb. = 1 Cent. „

1 Horse-power = 33000 foot pounds per minute = 746 watts.

Volts × ampères = watts.

1 Atmosphere = 14·7 lb. per square inch = 2116 lb. per square foot = 760 mm. of mercury = 10^6 dynes per sq. cm. nearly.

A column of water 2·3 feet high corresponds to a pressure of 1 per sq. inch.

Absolute temp., $t = \theta° \text{ C.} + 273°·7$.

Regnault's $H = 606·5 + ·305\ \Theta° \text{ C.} = 1082 + ·305\ \Theta° \text{ F.}$

$p\, u^{1·0646} = 479.$

$$\log_{10} p = 6·1007 - \frac{B}{t} - \frac{C}{t^2},$$

where $\log_{10} B = 3·1812$, $\log_{10} C = 5·0881$.

p is in pounds per square inch, t is absolute temperature Centigra

u is the volume in cubic feet per pound of steam.

$\pi = 3·1416$.

One radian = 57·3°.

To convert common into Napierian logarithms, multiply by 2·302

The base of the Napierian logarithms is $e = 2·7183$.

The value of g at London = 32·182 feet per sec. per sec.

LOGARITHMS.

	0	1	2	3	4	5	6	7	8	9	1 2 3 4	5	6 7 8 9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4 9 13 17 4 8 12 16	21 20	26 30 34 38 24 28 32 37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4 8 12 15 4 7 11 15	19 19	23 27 31 35 22 26 30 33
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3 7 11 14 3 7 10 14	18 17	21 25 28 32 20 24 27 31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3 7 10 13 3 7 10 12	16 16	20 23 26 30 19 22 25 29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3 6 9 12 3 6 9 12	15 15	18 21 24 28 17 20 23 26
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3 6 9 11 3 5 8 11	14 14	17 20 23 26 16 19 22 25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3 5 8 11 3 5 8 10	14 13	16 19 22 24 15 18 21 23
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	3 5 8 10 2 5 7 10	13 12	15 18 20 23 15 17 19 22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2 5 7 9 2 5 7 9	12 11	14 16 19 21 14 16 18 21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2 4 7 9 2 4 6 8	11 11	13 16 18 20 13 15 17 19
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2 4 6 8	11	13 15 17 19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2 4 6 8	10	12 14 16 18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2 4 6 8	10	12 14 15 17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2 4 6 7	9	11 13 15 17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2 4 5 7	9	11 12 14 16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2 3 5 7	9	10 12 14 15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2 3 5 7	8	10 11 13 15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2 3 5 6	8	9 11 13 14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2 3 5 6	8	9 11 12 14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1 3 4 6	7	9 10 12 13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1 3 4 6	7	9 10 11 13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1 3 4 6	7	8 10 11 12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1 3 4 5	7	8 9 11 12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1 3 4 5	6	8 9 10 12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1 3 4 5	6	8 9 10 11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1 2 4 5	6	7 9 10 11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1 2 4 5	6	7 8 10 11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1 2 3 5	6	7 8 9 10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1 2 3 5	6	7 8 9 10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1 2 3 4	5	7 8 9 10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1 2 3 4	5	6 8 9 10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1 2 3 4	5	6 7 8 9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1 2 3 4	5	6 7 8 9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1 2 3 4	5	6 7 8 9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1 2 3 4	5	6 7 8 9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1 2 3 4	5	6 7 8 9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1 2 3 4	5	6 7 7 8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1 2 3 4	5	5 6 7 8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1 2 3 4	4	5 6 7 8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1 2 3 4	4	5 6 7 8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1 2 3 3	4	5 6 7 8

Logarithms.

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	4

ANTILOGARITHMS.

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
·00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
·01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
·02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
·03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
·04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
·05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
·06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
·07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
·08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
·09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
·10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
·11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
·12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
·13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
·14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
·15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
·16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
·17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
·18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
·19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
·20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
·21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
·22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
·23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
·24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
·25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
·26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
·27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
·28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
·29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
·30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
·31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
·32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
·33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
·34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
·35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
·36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
·37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3	3	4	4	5
·38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
·39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
·40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
·41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
·42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
·43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
·44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
·45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	5	5	6
·46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	1
·47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	6	
·48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4	4	5		
·49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4	4	5		

ANTILOGARITHMS.

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
·50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
·51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
·52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
·53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
·54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
·55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
·56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
·57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
·58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
·59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
·60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
·61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
·62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
·63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
·64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
·65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	
·66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	1
·67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	1
·68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	1
·69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	1
·70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	1
·71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	1
·72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	1
·73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	1
·74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	8	9	10	1
·75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	1
·76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	1
·77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	1
·78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	1
·79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	1
·80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	1
·81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	1
·82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8	9	11	12	1
·83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	1
·84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	1
·85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	12	13	1
·86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	1
·87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	1
·88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	12	14	1
·89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	13	14	1
·90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9	11	13	15	1
·91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	1
·92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	12	14	15	1
·93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	1
·94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	1
·95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	1
·96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11	13	15	17	1
·97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	1
·98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	1
·99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	1

Angle		Chord.	Sine.	Tangent.	Co-tangent.	Cosine.			
Degrees	Radians.								
0°	0	0	0	0	∞	1	1·414	1·5708	90°
1	·0175	·017	·0175	·0175	57·2900	·9998	1·402	1·5533	89
2	·0349	·035	·0349	·0349	28·6363	·9994	1·389	1·5359	88
3	·0524	·052	·0523	·0524	19·0811	·9986	1·377	1·5184	87
4	·0698	·070	·0698	·0699	14·3007	·9976	1·364	1·5010	86
5	·0873	·087	·0872	·0875	11·4301	·9962	1·351	1·4835	85
6	·1047	·105	·1045	·1051	9·5144	·9945	1·338	1·4661	84
7	·1222	·122	·1219	·1228	8·1443	·9925	1·325	1·4486	83
8	·1396	·140	·1392	·1405	7·1154	·9903	1·312	1·4312	82
9	·1571	·157	·1564	·1584	6·3138	·9877	1·299	1·4137	81
10	·1745	·174	·1736	·1763	5·6713	·9848	1·286	1·3963	80
11	·1920	·192	·1908	·1944	5·1446	·9816	1·272	1·3788	79
12	·2094	·209	·2079	·2126	4·7046	·9781	1·259	1·3614	78
13	·2269	·226	·2250	·2309	4·3315	·9744	1·245	1·3439	77
14	·2443	·244	·2419	·2493	4·0108	·9703	1·231	1·3265	76
15	·2618	·261	·2588	·2679	3·7321	·9659	1·218	1·3090	75
16	·2793	·278	·2756	·2867	3·4874	·9613	1·204	1·2915	74
17	·2967	·296	·2924	·3057	3·2709	·9563	1·190	1·2741	73
18	·3142	·313	·3090	·3249	3·0777	·9511	1·176	1·2566	72
19	·3316	·330	·3256	·3443	2·9042	·9455	1·161	1·2392	71
20	·3491	·347	·3420	·3640	2·7475	·9397	1·147	1·2217	70
21	·3665	·364	·3584	·3839	2·6051	·9336	1·133	1·2043	69
22	·3840	·382	·3746	·4040	2·4751	·9272	1·118	1·1868	68
23	·4014	·399	·3907	·4245	2·3559	·9205	1·104	1·1694	67
24	·4189	·416	·4067	·4452	2·2460	·9135	1·089	1·1519	66
25	·4363	·433	·4226	·4663	2·1445	·9063	1·075	1·1345	65
26	·4538	·450	·4384	·4877	2·0503	·8988	1·060	1·1170	64
27	·4712	·467	·4540	·5095	1·9626	·8910	1·045	1·0996	63
28	·4887	·484	·4695	·5317	1·8807	·8829	1·030	1·0821	62
29	·5061	·501	·4848	·5543	1·8040	·8746	1·015	1·0647	61
30	·5236	·518	·5000	·5774	1·7321	·8660	1·000	1·0472	60
31	·5411	·534	·5150	·6009	1·6643	·8572	·985	1·0297	59
32	·5585	·551	·5299	·6249	1·6003	·8480	·970	1·0123	58
33	·5760	·568	·5446	·6494	1·5399	·8387	·954	·9948	57
34	·5934	·585	·5592	·6745	1·4826	·8290	·939	·9774	56
35	·6109	·601	·5736	·7002	1·4281	·8192	·923	·9599	55
36	·6283	·618	·5878	·7265	1·3764	·8090	·908	·9425	54
37	·6458	·635	·6018	·7536	1·3270	·7986	·892	·9250	53
38	·6632	·651	·6157	·7813	1·2799	·7880	·877	·9076	52
39	·6807	·668	·6293	·8096	1·2349	·7771	·861	·8901	51
40	·6981	·684	·6428	·8391	1·1918	·7660	·845	·8727	50
41	·7156	·700	·6561	·8693	1·1504	·7547	·829	·8552	49
42	·7330	·717	·6691	·9004	1·1106	·7431	·813	·8378	48
43	·7505	·733	·6820	·9325	1·0724	·7314	·797	·8203	47
44	·7679	·749	·6947	·9657	1·0355	·7193	·781	·8029	46
45°	·7854	·765	·7071	1·0000	1·0000	·7071	·765	·7854	45°
			Cosine	Co-tangent	Tangent	Sine	Chord	Radians	Degrees
								Angle	

SUBJECT VIII.—SOUND, LIGHT, AND HEAT.

The examination papers in Stage 1 will contain questions in Sound, and in Light, and in Heat. No candidate will be allowed to pass who fails to show a competent knowledge in at least two of these sections.

In Stages 2 and 3, and in the examination for Honours, the subject will be taken in three sub-divisions, and a candidate will be allowed to take up one or more of the sub-divisions, viz., Sound, Light, or Heat, in the same or in different years. But no candidate will be credited with a success in the Honours examination in any sub-division unless he has passed Stage 3 (or Honours, Part I.) in that sub-division.

It must be distinctly understood that candidates when answering questions on the explanation of physical phenomena are expected to be acquainted with the mechanical principles on which these explanations are based, and also that problems may be set involving a knowledge of the facts or formulæ referred to in the syllabus.

Compulsory questions may be set at the examination.

NOTE.—An outline of elementary experiments, together with a description of the necessary apparatus, for illustrating this subject has been prepared; this (Price 6*d.*) and a syllabus of the course of practical instruction in Physics at the Royal College of Science, South Kensington (Price 1*s.*), may be obtained.

STAGE 1.

SOUND.

Sound produced by vibration. Sound transmitted through solids, liquids and gases.

Study more particularly air.

Sound waves produce only vibratory motions in the air particles.

Longitudinal and transversal vibrations.

Sound wave consists of alternate compressions and rarefactions.

Simple harmonic vibration of a pendulum. Amplitude of vibration.

Vibration frequency. Wave length. Relation between wave length, frequency and velocity.

Velocity of sound. Methods of measuring velocity on a large scale in (1) air, (2) water.

High and low notes travel with the same velocity.

The loudness of a sound depends upon the amplitude of the vibration of the particles.

The pitch of a sound depends upon the frequency of the vibrations.

Reflection of sound. Angles of incidence and reflection equal. Echoes. Whispering galleries. Speaking tube.

LIGHT.

Propagation in straight lines. Shadows. Penumbræ. Images formed by pinholes.

Intensity of light. Law of change of intensity with change of distance from a luminous point. Photometry.

Reflection of light. Plane mirrors. Parallel and inclined plane mirrors. Concave and convex spherical mirrors. Methods of determining the position of the principal focus of a concave mirror (1) by optical experiment, (2) from the radius of the mirror (supposed known). Formation of images. Real and virtual images. Conjugate foci treated experimentally. Geometrical construction for the image of a small object on the axis of the mirror when the position of the centre or principal focus is given.

Refraction of light. General form of the path of a ray of light passing through (1) a plate, (2) a prism, (3) a lens.

Thin convex lenses. Methods of determining by experiment the position of the principal focus of a convex lens.

Formation of images. Real and virtual images.

Conjugate foci treated experimentally. Geometrical construction for the image of a small object on the axis of the lens when the position of the lens and of its principal foci are given.

Refractive index.

Geometrical constructions for the path of a ray of light through (1) a plate, (2) a prism.

Heat.

Distinction between heat and temperature.

Construction of mercurial thermometer.

Different thermometric scales.

Expansion of solids. Linear and cubical expansion.

Effects of unequal expansion.

Expansion of liquids. Difference between absolute and apparent expansion.

Peculiarity in the expansion of water.

Expansion of gases.

Specific heat. Calorimeters. Method of mixtures. Consequences of the high specific heat of water.

Fusion and solidification. Melting points. Meaning of the term latent heat. Change of volume during fusion. Effects of frost.

Boiling points. Meaning of the term latent heat of vaporization.

Convection of heat in liquids and gases.

Heating buildings by hot water. The Gulf Stream and ocean currents.

Conduction of heat. Effects due to the high or low conducting power of various substances.

STAGE 2.

Stage 2 in each sub-division is as follows. But a candidate will be expected to have a knowledge of all the matters which are included in Stage 1. Thus a candidate who takes up Sound in Stage 2 will be expected to have a knowledge of Light and Heat equivalent to that required in Stage 1, and so on.

VIII*a*.—Sound.

Boyle's law. Hooke's law.

Meaning of the terms stress, strain, co-efficient of elasticity. Measures of these quantities in a gas.

Newton's relation between the velocity, elasticity, and density.

General explanation of Laplace's correction of Newton's formula.

Effect of changes of temperature, and of pressure on the velocity of sound in a gas.

Methods of measuring velocity of sound.

Reflection and refraction of waves. Explanation and application to the reflection and refraction of sounds. Refraction of sound by wind.

Musical tones. Methods of measuring pitch. Musical scales. Temperament.

Interference of waves. Stationary vibrations. Beats. Relation between the frequency of beats and the frequency of the notes which produce them.

Transversal vibrations of strings.

Change of pitch due to changes in the length, diameter, material, and stretching force of a string vibrating transversely.

Harmonics.

Melde's apparatus.

Transversal vibrations of rods.

Tuning forks.

Longitudinal vibrations of strings, rods, and columns of air.

Change of pitch due to changes in the length, diameter, material, and stretching force of a string vibrating longitudinally.

Mouth (or flue) organ pipes, open and stopped. Harmonics. Galton's whistle.

Vibrations of plates. Chladni's figures.

Change of pitch caused by approach or recession of sounding body.

Resonance. Analysis of compound notes by resonators. Sympathetic vibrations. *Timbre* or quality of notes.

VIII*b*.—Light.

Reflection. Goniometers. Hadley's sextant.

Proof of the algebraical relations between the focal length of a spher[illegible]cal mirror and the distances of an object and its image from it. Applicat[illegible]ons of the formula to simple cases.

Parabolic mirror.

Spherical aberration. Caustics.

Proof of the relations between the refractive index and the distance[illegible] of an object and its image from (1) a plane, (2) a spherical refracting surfac[illegible]e.

Total internal reflection. Critical angle.

Deviation. Calculation of the deviation of a ray on passage throug[illegible]h a prism.

Methods of measuring refractive indices.

Methods of determining the focal lengths of lenses.

The principle of the microscope, astronomical telescope and opera gla[illegible]s.

Dispersion. The composite character of white light. Calculation of the dispersion of a ray on passage through a thin prism.

Achromatism. General principles of construction of achromatic lense[illegible]s.

The wave theory of light.

Methods of measuring the velocity of light (1) in interplanetary space[illegible] (2) in air, (3) in other media.

Explanation of the laws of reflection and refraction by the wave-the[illegible]ory of light. Physical meaning of the refractive index.

Interference of light. Colours of thin plates. Newton's rings. Fresn[illegible]el's interference bands.

Diffraction. The diffraction spectrum. Method of measuring the w[illegible]ve length of light.

Polarization. Passage of light through tourmaline and Iceland sp[illegible]ar. Ordinary and extraordinary rays. Nicol's and other polarizing pris[illegible]ms. Simple forms of polariscope and saccharimeter.

Relations between light and ordinary matter. Spectrum analy[illegible]sis. Spectra produced by glowing solids, liquids, and gases.

Effects of the incidence of radiation on matter. Absorption accompan[illegible]ied by (*a*) heat, (*b*) chemical action. Selective absorption.

Extension of the spectrum beyond its visible limits.

Relations between radiation and absorption by the same body. Abso[illegible]rp-tion spectra.

Colour vision Colour mixtures. Complementary colours.

Fluorescence, phosphorescence, phosphoroscope.

VIII*c*.—Heat.

Sources of errors in the mercurial thermometer. Maximum and minim[illegible]m thermometers.

The air thermometer at (1) constant volume, (2) constant pressure. Ab[illegible]so-lute zero of temperature deduced from the air thermometer.

Methods of measuring the expansion of solids, liquids, and gases.

Calorimetry. Accurate methods of measuring the specific heats of sol[illegible]ds and liquids.

Specific heats of gases at constant pressure and constant volume.

Atomic heat. Dulong and Petit's law.

Nature of heat. Methods of measuring energy. Different kinds of energy. Transformation of energy of visible motion into heat.

The mechanical equivalent of heat.

The first law of thermodynamics.

Transference of heat. Physical nature of conduction. Physical nature of radiation.

The reflection of non-luminous radiation.

Fusion and solidification. Changes in the melting points of bodies produced by pressure.

Black's and Bunsen's calorimeters.

Vaporization and liquefaction. Evaporation. Saturated and non-saturated vapours. General form of the isothermal curves of vapours and gases.

Condensation of aqueous vapour. The dew-point and its measurement. The hygrometric state of the air. The wet and dry bulb hygrometer. Condensation hygrometer. Clouds. Rain. Snow and hail.

Expenditure of the latent heat of vaporization on internal and external work.

Spheroidal state.

Gases. Joule's experiments on the internal work of expanding gases. Relation between the specific heats of gases at constant volume and constant pressure.

Adiabatic expansion or compression. Experiment of Clement and Désormes.

Determination of the ratio between the specific heats from the velocity of sound.

The method of calculating J from observations of gases.

General principles of the galvanometer, thermopile, electrical resistance thermometer.

STAGE 3.

The examination will consist of a written paper in which questions may be set on any branch of the subject taken up by the candidate (*e.g.*, on any part of Sound, if Sound is the subject presented). No question will be set necessitating a knowledge of the differential or integral calculus, but candidates may employ the calculus in their answers.

HONOURS.

In this examination two papers will be set. Paper I., which will be set at the Evening Science Examinations, will consist of questions on the higher branches of the subject generally, and candidates will be expected to answer questions in any branch of the subject, on its relations to other physical sciences, and to treat mathematical problems associated therewith by the differential or integral calculus, including differential equations.

Candidates who answer the questions in Paper I. in a sufficiently satisfactory way will be required to undergo a further examination at South Kensington, which will consist of a written examination (Paper II.) and an examination in practical work. In the former candidates must select one or more of certain subjects proposed as essays, and in awarding marks for these the method of treatment and the style will be considered as well as the knowledge of scientific facts and theories.

No candidate can be classed in Honours who is not successful in all the above-named examinations.

For suggested Laboratory arrangements for practical work in Physi see page 46.

SUBJECT IX.—MAGNETISM AND ELECTRICITY.

NOTE.—An outline of elementary experiments, together with a description of the necessary apparatus for illustrating this subject, has been prepared ; this (Price 6*d.*) and a syllabus of the course of practical instruction in Physics at the Royal College of Science, South Kensington (Price 1*s.*), may be obtained.

It must be distinctly understood that candidates when answering questions on the explanation of physical phenomena are expected to be acquainted with the mechanical principles on which these explanations are based, and also that problems may be set involving a knowledge of the facts or formulæ referred to in the syllabus.

Compulsory questions may be set at the examination.

STAGE 1.

MAGNETISM.

Magnetic substances. Action of magnets on one another. North and South poles and magnetic axis of a magnet. Magnetic meridian.

Magnetic field. Lines of force ; their delineation by iron filings or a small compass.

Magnetic induction. Magnetic qualities of hard steel and soft iron. Effects of the introduction of soft iron into a magnetic field.

Methods of magnetization by permanent magnets. Distribution of magnetism in magnets. Consequent poles. Effect of breaking or subdividing a magnet. Effect of the keeper of a magnet on the distribution of the lines of force.

Terrestrial magnetism. Mariner's compass ; Declination ; Dip ; Magnetic Poles and Equator. General explanation of the behaviour of compass and dip needle on the assumption that the earth is a magnet. Effect of the earth's magnetic field on masses of iron. Direction of the earth's magnetic force at a place. Horizontal and vertical components of the force.

FRICTIONAL ELECTRICITY.

Electrification by friction. Positive and negative electrification. Simultaneous development of positive and negative electricity in equal quantities. Attraction and repulsion. Electric charge or quantity. The gold leaf electroscope.

Conductors. Non-conductors.

Distribution of electricity on conductors. Hollow conductors. Points.

Difference of potential. Analogies with temperature, level and pressure. Work done by or against electric forces.

Electrostatic induction. Ice pail experiments.

Leyden jar and plate condenser. Condensing electroscope.

Electrophorus. Frictional electric machine. Electric discharge.

VOLTAIC ELECTRICITY.

Simple voltaic cells. Local action and polarization. Constant cells. General description of the chemical action taking place in the most common forms of cells.

Electromotive force (potential difference). Electric circuit, current, resistance. Connection of cells in series.

Magnetic field due to a current in a straight wire and in a circular coil. Oersted's experiment. Galvanometer. Forces acting on the needle of a galvanometer. Advantages of an astatic pair of needles.

Ohm's law and its application to simple circuits.

The heating effect of a current in a conductor proportional to the resistance of the conductor and to the square of the current.

Eletro magnet. Magnetizing coil.

Decomposition by an electric current of acidulated water, copper sulphate, &c

STAGE 2.

Magnetism.

The subjects of Stage 1, together with the following :—

Definition of unit pole. Force between two magnetic poles. The opposite poles of a magnet are of equal strength. Magnetic moment of a magnet. Comparison of magnetic moments. Law of oscillation of magnet in a magnetic field. Couple between two short linear magnets so placed that the axis of one passes through the centre of the other at right angles.

Behaviour of magnetic substances when subjected to changes in magnetic force. Residual magnetism, coercive force, permeability.

Effect of temperature on a magnet. Critical temperature of iron.

Terrestrial magnetism. Determination of declination, dip and comparison of horizontal forces at different places on the earth's surface. General description of the magnetic state of the earth.

Frictional Electricity.

The subjects of Stage 1 with the following :—

Electric force. Forces between point-charges of electricity. Electric field due to a charged body. Lines of electric force. Electric force and charge inside a conductor. Electric density. Capacity of conductor. Specific inductive capacity or dielectric constant. Capacity of condensers in series and in parallel. Energy of an electric charge. Potential at a point in an electric field.

Description of construction and principles involved in the use of electrostatic induction (influence) machines, condenser, quadrant electrometer, &c.

Voltaic and Technical Electricity.

The subjects of Stage 1 with the following :—

Practical units of electromotive force, current, resistance, quantity, capacity, energy, power, &c.

Methods for the comparative measurement of the strength of currents, electromotive forces, and resistances in metallic conductors and electrolytes. Principles on which these methods depend ; construction and use of instruments required for their practical application.

Comparison of electric capacities.

Joule's law and its verification. Mechanical equivalent of heat. Phenomena of the electric arc. Absorption and evolution of heat at metallic junctions in a circuit. Thermo-electric currents.

Electrolysis, especially of acidulated water, copper sulphate, and silver nitrate. Voltameter. Polarization.

Forces acting on magnets and conductors carrying currents in a magnetic field. Mutual action of currents and currents, currents and magnets, &c.

Induced electromotive force and current. Lenz's law. Ruhmkorff's coil.

General principles of the construction, and description of simple forms of continuous current dynamos and motors.

Transmission of power.

Electric lighting by arc and glow lamps.

General principles and description of the simpler forms and apparatus used in telegraphy and telephony.

Storage batteries.

Principles and construction of the simpler forms of electric or magnetic measuring instruments.

STAGE 3.

The examination will consist of a written paper in which questions may be set on any branch of the subject. No question will be set necessitating a knowledge of the differential or integral calculus, but candidates are permitted to use the methods of the calculus in their answers.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.).

In this examination two papers will be set. Paper I., which will be set at the Evening Science Examinations, will consist of questions on the higher branches of the subject generally, and candidates will be expected to answer questions in any branch of the subject, on its relations to other physical sciences, and to treat mathematical problems associated therewith by the differential or integral calculus, including differential equations.

Candidates who answer the questions in Paper I. in a sufficiently satisfactory way will be required to undergo a further examination at South Kensington, which will consist of a written examination (Paper II.) and an examination in practical work. In the former candidates must select one or more of certain subjects proposed as essays, and in awarding marks for these the method of treatment and the style will be considered as well as the knowledge of scientific facts and theories.

No candidate can be classed in Honours who is not successful in all the above-named examinations.

Suggested Laboratory Arrangements for Practical Work in Physics.

Laboratory. The laboratory should be a well-lighted room, fairly lofty and with adequate ventilation. It should be situated preferably on the lowest floor of the building, in order to secure freedom from vibration. There should be sufficient space between the benches to allow of easy passage.

The lighting might conveniently be from two adjacent sides of the room, leaving abundant wall space for blackboard, diagrams, cupboard space, and certain experiments with pendulums, levers, &c., needing blank wall.

Arrangements should be made for providing a dark room for photometric or other measurements requiring artificial illumination. This may be done either by fitting dark blinds to the windows of the laboratory or by screening off a portion of the darker side of the room with thick brize curtains.

The working benches recommended should be in the nature of plain strongly-framed tables, about 2ft. 9in. high, placed as far as possible in the middle of the room, and stone benches built into two side walls or wooden ones strongly fastened. The tops of the benches should be of hard well-seasoned wood and unpolished. The benches should be suitably equipped for the experiments to be performed on them—a permanent place should be assigned to apparatus whose accuracy may be impaired by moving it. A mercury table is a useful adjunct.

Gas should be laid on to each bench.

An over-head rail for suspension, fitted with hooks and clamps, is a useful addition to at least some of the benches.

At least two large sinks with water supply and waste should be provided in a laboratory for 20 students.

It will be necessary to provide considerable cupboard space, also lockers both for the sets of apparatus supplied to each student, and for apparatus to be distributed when required.

The apparatus supplied to each student must vary in accordance with the nature of the practical course. It is not expedient to place too much apparatus in the student's hands in the first instance; the bulk of what is needed should be reserved for special distribution.

SUBJECT X.—INORGANIC CHEMISTRY, THEORETICAL.

COMPULSORY QUESTIONS MAY BE SET AT THE EXAMINATION.

STAGE 1.

PRELIMINARY.—Chemical changes distinguished from temporary physica changes.

*Experiments.**—Show that a given weight of water neither gains nor loses weight when changed from the state of ice to that of water and steam or *vice versâ*. Show that a piece of copper heated with free exposure to air becomes encrusted with a scale. Show ignition of copper foil in sulphur vapour and compare the product with sulphur and with copper. Show that quicklime sprinkled with water becomes hot and that the product, when finished, is a dry powder, the weight of which is one-third greater than that of the lime. Show that limestone dissolves in acid with effervescence giving off a gas. After burning in the kiln it may be dissolved in acid, but no longer yields the gas. Heat a small piece of white marble, in a porcelain crucible, strongly over the blow-pipe flame and show that it has lost weight while becoming lime.

INDESTRUCTIBILITY OF MATTER.

Experiments.—Place in a dry flask, fitted with a good cork, a small piece of phosphorus, and weigh. Ignite phosphorus, and when cold show that there is no change of weight. Burn a candle or sulphur in a proper apparatus, provided with absorbents, and show that the whole remains unchanged in weight. Or better, in a strong globular flask filled with oxygen and closed by a good cork, suspend by copper wires a *small* piece of charcoal held in a coil of thin platinum wire. Counterpoise the whole, then ignite the charcoal by an electric current, and after it is burnt out and cold show that there is no loss of weight.

Dissolve about half a gram of copper in the least possible quantity of nitric acid, add excess of dilute sulphuric acid, and precipitate the copper completely by heating with zinc; or dissolve about the same amount of silver and precipitate from the solution diluted with water by means of magnesium. In each case show that there is no loss of metal. Similarly, dissolve about half a gram of anhydrous peroxide of iron in hydrochloric acid, precipitate the solution by ammonia, and recover the oxide by filtration. Burn off the paper and weigh the oxide in a porcelain crucible.

PROPERTIES OF GASES.—Air is a gas; it occupies space and has weight. Other gases lighter or heavier, and differ in other ways, *e.g.*, colour, inflammability, solubility in water. Action of pressure on gases (Boyle's Law); action of heat on gases (Charles' Law); diffusion of gases (Graham's Law).

Experiments.—A small globular flask fitted with stopcock and weighed; exhaust by means of a brass syringe and show difference of weight. Pneumatic syringe to show compressibility of air. Marriotte's tube to illustrate pressure by mercury, and prove the law. Barometer tube filled and inverted in mercury. Show by means of U tube open at both ends that one inch of mercury balances more than one foot of water. Expansion of air shown by flask fitted with cork and long narrow tube dipping into coloured water. The co-efficient of expansion should be determined by observation of the increase of volume in a

* Some of these experiments are only suitable for demonstration to a class; many, however, and especially those which involve weighing of small quantities, are best performed by the students. A detailed account of conditions necessary to success in many of the experiments will be found in some of the modern text books.

measured quantity of air heated from 0° to 100°. This may be done in an inverted burette, containing mercury by which the air is confined, and passed through a condenser jacket supplied first with ice water, then with steam. A vertical tube for equalising pressure must be connected by a rubber stopper with the mouth of the burette. Illustrate diffusion of gases by means of tube with clay battery cell fitted to one end by means of rubber bung. Show that heavy gases like carbon dioxide diffuse more slowly than light gases, like hydrogen, in exchange for air.

AIR.—Relation of air to flame and combustion generally. Power of keeping up combustion limited. Air changed by burning a candle in it; it then extinguishes flame. Metals heated in air generally altered in appearance, *e.g.*, copper, lead or zinc, and thus changed increase in weight. The air also changed and diminished in volume. Phosphorus produces a similar effect, slowly at common temperatures, immediately by burning. Air is therefore made up of at least two parts; the part left after the action of a metal or phosphorus extinguishes a flame, and small animals die in it. Air from the lungs of an animal extinguishes flame.

Experiments.—Burn a candle in a wide-mouth bottle closed by a glass plate; the candle soon extinguished, but show by inversion in water that the bottle is still full of air. Repeat the experiment; lift out the candle, relight it, and plunge it into the residual air. Heat a sheet of copper over a Bunsen flame and show change of appearance. Place a strip of bright copper in a short piece of combustion tube sealed at one end; exhaust the air from the other by means of a brass syringe. Heat the copper, and no change of appearance will be observed. Counterpoise a 6-inch roll of clean copper gauze contained in a short piece of combustion tube. Heat to redness while air is passed slowly through the tube. Collect the air after leaving the copper in gas jars, and show the change in it; also that the metal, when cold, has gained in weight.

Expose a stick of phosphorus supported on a wire to contact with a measured volume of air confined over water. After 12 hours measure the residual air and test it with a candle. Divide a metre-long tube into five equal parts by rubber bands, put in a small dry piece of phosphorus, cork the tube, melt the phosphorus by dipping the tube into hot water, jerk the tube so as to spread the ignited phosphorus. When cool dip the corked end under water, and, removing the cork, show the rise of the water one division.

Collect air from the lungs in a stoppered gas jar over water and show that it extinguishes a candle flame.

OXYGEN obtainable from air by means of mercury or lead. Usually made by heating potassium chlorate. Properties of oxygen.

Experiments.—Show that red precipitate and red lead both give off oxygen, heating a gas which kindles a spark into a flame on a spill of wood. The formation and collection of red precipitate by Lavoisier's experiment cannot well be shown, but litharge may be obtained in a few hours by roasting a strip of thin sheet lead on an iron plate. From litharge the production of red lead is easily shown by heating the powder in a short piece of combustion tube through which air is drawn. A more rapid effect is obtained by heating in air a mixture of 3 parts litharge and 1 part caustic potash till it is black. The powder thus obtained heated strongly in a tube evolves oxygen. Make oxygen from chlorate alone and mixed with $\frac{1}{10}$ part of manganic oxide; in the latter case the oxygen is accompanied by a minute quantity of chlorine, which can be smelt, but will not interfere with the use of the gas for most purposes.

Demonstrate combustions in oxygen. Heat strip of bright copper in oxygen and show production of the black crust.

HYDROGEN. Preparation and properties.

Experiments.—Show production of gas by dissolving iron or zinc in dilute sulphuric or hydrochloric acid. Identity of the gas obtained by different methods rendered probable from its formation of water and nothing else, when passed through hot oxide of copper.

Show lightness by balloon or soap bubbles, &c.; combustibility; extinction of candle flame in hydrogen; combustion of oxygen in hydrogen.

ATER.—Substance of definite melting and boiling points, density, &c., ral, remarkable as a solvent. Composed of 2 vols. hydrogen to 1 vol. gen, or 2 parts, by weight of hydrogen to nearly 16 parts of oxygen. on of metals on water.

Experiments.—Show that several specimens of ice or snow have the same melting point. Demonstrate boiling point under various conditions as to pressure. Burn hydrogen in air and show production of water. Pass hydrogen over copper gauze blackened by previous heating in air (*see* Air) and collect water. Show union of hydrogen and oxygen in Cavendish eudiometer and formation of dew. Pass steam through iron tube containing nails heated to redness and collect hydrogen. Ignite magnesium in steam passed through short combustion tube, kept hot to prevent condensation of water, and burn escaping hydrogen. Show residual oxides produced in both cases. Show action of sodium on water and collect a little hydrogen. This is done most safely by cutting off half inch lengths of narrow composition pipe, closing one end of each by pinching, and stuffing a small piece of sodium into the open end. Tubes thus charged can be thrown one at a time into water, and the gas collected in a small jar filled with water and inverted over them.

LAWS OF CHEMICAL COMBINATION.

Definite Proportions by Weight.

Experiments.—Take two pieces of clean magnesium ribbon of equal weight. Heat one piece in a covered porcelain crucible over Bunsen flame till the metal is burnt completely, at first with the lid on to avoid loss, then open. Cool and weigh. Dissolve the other piece of metal in dilute sulphuric acid, add excess of sodium carbonate, boil, filter, wash, dry, and calcine the filter and precipitate in the same crucible. The oxide should be white and weigh the same as that formed directly from the metal.

Dissolve zinc, oxide of zinc, and carbonate of zinc separately in dilute sulphuric acid and crystallise slowly so as to get distinct prisms. Show that the crystals have in each case the same form and yield, when dried at 100°, the same weight of water of crystallisation.

Weigh out in a crucible about ·5 gram white marble, heat strongly by means of a blow-pipe flame for about ten minutes, cool and weigh. Moisten with solution of ammonium carbonate, dry at 100° and weigh. The weight should be equal to that of the marble taken.

Equivalents.

Experiments.—Compare combining weight of silver with that of copper by immersing a weighed quantity of fine copper wire in a neutral solution of silver nitrate, heating gently till the copper has entirely dissolved, and weighing the precipitated silver. Similarly compare combining weight of copper with that of zinc by digesting at a gentle heat, a weighed piece of zinc foil in an excess of solution of copper sulphate. Determine the weight of zinc required to displace one part, by weight, of hydrogen, by experimental determination of the loss of weight of small light apparatus, provided with suitable drying tube, in which the metal is dissolved in dilute sulphuric acid.

Determine the volume of hydrogen displaced from dilute hydrochloric acid by equivalent weight of zinc. From the result the weight of unit volume of hydrogen or the volume of unit weight of hydrogen may be calculated. The equivalents of other metals, such as magnesium and aluminium, which are dissolved by dilute acid, may be subsequently determined by measuring the hydrogen they displace.

3. Multiple Proportions.

Experiments.—Prepare some pure and dry peroxide of lead. Place in a crucible about 2 grams and weigh carefully. Heat to low redness till the change of colour is complete, but the oxide is not melted; cool and weigh. Half fill the crucible with potassium cyanide; mix up the oxide and cyanide and gradually heat over blow-pipe flame to bright redness, maintaining the mixture completely liquid for a quarter of an hour, or until the whole of the lead has collected into one or several large beads. The process is promoted by stirring with an iron wire. Cool, wash out the soluble salts with hot water, and weigh the beads of lead alone. The loss of weight in the two cases should be exactly equal, and will be nearly so if care is taken in collecting the lead. Or the litharge may be reduced to the metallic state by heating it, in a porcelain boat within a glass tube, in a stream of coal-gas.

Weigh out a few grams of powdered copper sulphate and heat in a steam oven till loss of weight is no longer observed. Heat the residue over a flame gently till white, then weigh again. The first loss should be to the second as 4 to 1.

Cuprous and cupric chlorides, mercurous and mercuric bromides may be analysed, but the operations involved are more difficult.

4. Law of Volumes.

Gases unite in equal volumes or in volumes which have a simple relation to one another.

Experiments.—Show that equal volumes of ammonia and hydrogen chloride gases combine together over mercury, any excess of either remaining unchanged.

Electrolyse acidified water and show that two volumes of hydrogen are given off for every volume of oxygen.

Burn carbon or sulphur in oxygen in an apparatus arranged to show that the volume of the gas remains unchanged, hence that carbon dioxide contains a quantity of oxygen equal in volume to itself.

Mixture and Combination Distinguished.—Compounds have (1) definite composition; (2) always same properties, *i.e.*, crystalline form, colour, solubility, &c., and (3) are not divisible by solution, filtration, diffusion, distillation, or other mechanical process into two kinds of substance. The constituents of mixtures are generally separable to a sufficient extent to show differences of density, colour, solubility, &c.

Experiments.—Black gunpowder treated with water gives up nitre; with carbon bisulphide gives up sulphur.

Powder some ferrous sulphide, and by repeatedly drawing a magnet over the surface of the powder remove uncombined iron; the residue should be preserved for comparison with a mixture of fine iron filings with half its weight of sulphur. From the mixture iron may be withdrawn by a magnet or by simply shaking about on a sheet of paper, when the iron and sulphur separate by reason of difference of density.

Compare a mixture of equal volumes of hydrogen and chlorine with hydrogen chloride gas.

Show that oxygen mixed with nitrogen in the proportions of 1 vol. to 4 vols. shows no sign of combination, and the mixture in all ordinary respects resembles air.

CHLORINE AND HYDROGEN CHLORIDE.

Experiments.—Take common salt as a typical chloride; show its solubility, neutrality, and precipitation of silver. Pour sulphuric acid on common salt and show that the evolved colourless gas fumes do not ignite at a flame and do not bleach vegetable dyes. Pass a little hydrogen chloride gas through a tube containing manganese dioxide, and show the resulting chlorine. Hydrogen chloride shown to be very soluble in water, the strong solution forming the "hydrochloric acid" or "spirit of salt" of the shops. Show that zinc, iron and other metals in contact with this solution cause the evolution of hydrogen. Afterwards make chlorine from salt, sulphuric acid and manganese dioxide, or from hydrochloric acid and manganese dioxide. Demonstrate the properties of the element chlorine (bromine, iodine, to be merely exhibited and vapours shown), including its combination with hydrogen.

ATOMIC THEORY.—Explain chemical combination by the Atomic Theory; use of symbols and equations. Formulæ for hydrogen chloride HCl, water H_2O, ammonia NH_3, carbon dioxide CO_2 stand for equal volumes of these gases. Division of elements broadly into non-metals and metals. Non-metals gaseous, liquid or solid; when solid, bad conductors of heat and electricity, brittle, usually destitute of lustre such as that of common metals. Combine with oxygen to form compounds generally soluble in water, producing acids, *e.g.*, sulphurous oxide, phosphoric oxide, carbon dioxide. Combine with hydrogen forming gaseous or volatile compounds.

Simple calculations of quantities by weight from formulæ and equations. Relations of weight to volume of gases from data to be given.

CARBON.—Demonstrate chief properties of charcoal, graphite and diamond.

CARBON AND OXYGEN.

Experiments.—Carbon dioxide shown to be a colourless, nearly odourless gas, heavier than air, produced by adding any acid to any carbonate, also by heating limestone or chalk. Gas extinguishes candle flame, slightly soluble in water, forming a feebly acid solution, forms precipitate in lime water, and is absorbed by solution of potash, soda or slaked lime. Converted into carbon monoxide by contact with red-hot charcoal.

Carbon monoxide or carbonic oxide, a gas formed, as above, from dioxide, but best made in a pure state in other ways which need not be described. Slightly lighter than air, burns when ignited in air, with characteristic blue flame, almost insoluble in water, neutral, not absorbed by lime water or alkalis.

SULPHUR.—Properties of common roll or flowers. Changes induced by heat, called allotropic, are unaccompanied by change of weight.

Experiments.—Demonstrate production of prismatic and plastic sulphur, and their reconversion by time into the common octahedral kind.

SULPHUR. COMPOUNDS WITH OXYGEN AND HYDROGEN.

Experiments.—Sulphur dioxide made by burning sulphur in air or by heating strong sulphuric acid with copper. Pungent gas heavier than air, extinguishes flame, soluble in water, solution acid, bleaches vegetable colours. Gives precipitate with lime water, and is absorbed by lime and by alkalis.

Sulphur trioxide, a white crystalline substance, of which a specimen should be shown.

Hydrogen sulphide or sulphuretted hydrogen. A stinking gas formed by passing hydrogen over heated sulphur, or more easily by adding dilute sulphuric acid or hydrochloric acid to iron sulphide (not "pyrites"). Gas heavier than air, inflammable, burning with a blue flame, forming water and sulphur dioxide, soluble in water, solution acid to test paper. Gas absorbed by lime and by alkalis. Blackens salts of lead, copper, and other heavy metals.

Acids are salts of hydrogen, characterised by the readiness with which they exchange this hydrogen for metals, forming metallic salts.

Experiments.—Demonstrate the general properties of the common acids—solubility, acidity, action on metals, and on metallic oxides.

Hydrochloric acid [already done], nitric acid, sulphurous acid, sulphuric acid, carbonic acid, production and properties [manufacture of sulphuric acid not included].

Demonstrate the properties of a few common salts, including chlorides, nitrates, sulphates, carbonates, especially NaCl, $CaCl_2$, KNO_3, $NaNO_3$, $AgNO_3$, Glauber's salt, Epsom salt, green, white and blue vitriols, alum, soda crystals, sodium bicarbonate, chalk, white lead.

Nitrogen. Compounds with Oxygen and with Hydrogen.

Experiments.—Demonstrate the following facts:—Nitrous oxide, a colourless gas made by heating ammonium nitrate, stimulates flame, somewhat like weak oxygen, soluble in water, neutral.

Nitric oxide a colourless gas made by pouring diluted nitric acid upon copper, very slightly soluble in water: distinguished from all other gases by uniting with oxygen to form a red gas which dissolves in water, giving an acid solution.

Nitric peroxide, the red fumes formed as above or by action of strong nitric acid on many metals.

Ammonia, a colourless, pungent, very soluble gas; both gas and solutions neutralise all acids; the gas mixed with equal volume of hydrogen chloride makes solid ammonium chloride from which, by action of potash, soda, or lime, hydrogen chloride is withdrawn and ammonia set free.

Metals.—General characters. All solid at common temperatures except mercury. When pure, are generally good conductors of heat and electricity, malleable and ductile. Oxides and hydroxides such as lime, caustic soda, zinc oxide, black copper oxide, litharge, mercuric oxide, inter-act with acids to form salts and water.

Experiments.—Show that lime, caustic soda, and litharge being more or less soluble in water turn red litmus blue, but that oxides of iron, copper, &c., being insoluble in water, produce no such effect. Demonstrate the production of water when an oxide inter-acts with an acid by placing a little litharge in a tube in which it can be heated, and which leads into a test tube kept cold. On passing hydrogen chloride gas and applying a gentle heat to the litharge, lead chloride is formed and water collects in drops in the receiver.

ALTERNATIVE STAGE 1.

After the year 1903-4 this Alternative Stage will probably be discontinued.

The following is an alternative syllabus for Stage 1 intended especially for those who do not desire to pursue the systematic study of Chemistry as a branch of Science. The syllabus represents broadly the Chemistry of common life.

A paper will be set in each syllabus at the annual examinations, and a candidate may take either, but not both. His success will be registered as a success in Stage 1 of Inorganic Chemistry.

Teachers who use this alternative syllabus may be reminded that it is not expected that the whole can be dealt with in one series of lessons. For the guidance of candidates at the examinations the questions are divided into groups, under such headings as the following:—

Air and Water.
Non-metallic Elements and their Compounds.
Acids, Bases, Salts.
Metals and their Compounds.
Substances of Organic Origin.

Air.—Surrounds the globe. Wind is air in motion. Air occupies space. The bulk of any quantity of air is much changed by temperature and by pressure. Air has weight. The necessity of air for animals and plants. Bodies when burning require air. Air a mixture chiefly of two gases, viz., xygen and nitrogen with small quantities of water vapour and carbon

dioxide. The proportion of nitrogen to oxygen. Oxygen the active constituent in air. Bodies burn in oxygen, and more brilliantly than in air. Increase of weight of bodies which unite with oxygen. The nearly constant composition of pure air. Presence of other gases in small amount in air. Water in the air as a gas. The drying-up of water.

*Experiments.**—That air occupies space may be shown by plunging a bell jar into a vessel of water. Fit a flask containing water with an indiarubber plug and delivery tube, heat the water, and collect the expelled air in a test tube inverted in a tumbler of water. Close the short limb of a syphon tube containing air, and compress the air in the short limb by pouring in mercury. Weigh a flask full of air, and fitted with a cork, glass tube, caoutchouc tube, and clip; exhaust by sucking out the air, and weigh again. Show that a lighted candle is soon extinguished when burnt under a lamp-glass resting on the table but that it continues to burn if fresh air be supplied by supporting the lamp-glass on two pieces of wood. Arrange an apparatus to show that if the products of combustion are collected no loss of weight occurs. Burn phosphorus in a tall bell jar over water, and show the diminution of bulk of air. Ignite phosphorus, show that it is extinguished in the remaining gas. Burn some phosphorus under a dry bell jar to show the compound of phosphorus and oxygen which is formed. Fix a pellet of phosphorus on the end of a piece of wire, and place in a test-tube graduated with a slip of paper and inverted in a tumbler of water to show that at ordinary temperatures it combines with the oxygen of the air and removes it, so that by measuring the volume of gas left, the amount of oxygen contained in air can be determined. Burn charcoal and sulphur in oxygen, and call attention to their disappearance. Demonstrate by lime water and by litmus paper respectively that a new body is in each case formed. Burn iron powder (*Ferrum reductum*) on a scale pan of a balance to show that an increase of weight occurs. Heat a sheet of copper over a Bunsen flame and show change of appearance. Place a strip of bright copper in a short piece of combustion tube sealed at one end; exhaust the air from the other by means of a brass syringe. Heat the copper, and no change of appearance will be observed. Counterpoise a 6-inch roll of clean copper gauze contained in a short piece of combustion tube. Heat to redness while air is passed slowly through the tube. Collect the air after leaving the copper in gas jars, and show the change in it; also that the metal, when cold, has gained in weight. A glass or metal vessel filled with ice or cold water can be used to show the condensation of moisture upon it. Place calcium chloride on the pan of a balance to show the gradual increase of weight which occurs by absorption of aqueous vapour from the air.

WATER.—Its three states. Expansion of water by heat and by freezing. Equal volumes at different temperatures have not the same weight. Formation of currents in water by heating. Boiling point. Increase of volume on conversion of water into steam. Distillation. Pure water. Hydrogen and its properties. The burning of hydrogen in air, and the weight of the product (water) compared with the weight of the hydrogen; the difference due to oxygen of the air with which hydrogen has combined. Combination of oxygen and hydrogen with explosion to form water. If by measure there be twice as much hydrogen as oxygen, or by weight eight times as much oxygen as hydrogen, then no gas remains—all becomes water. All water composed of these two bodies in this proportion. These two bodies can then be separated from water and can be made to

* Some of these experiments are only suitable for demonstration to a class; many, however, and especially those which involve weighing of small quantities, are best performed by the students. A detailed account of conditions necessary to success in many of the experiments will be found in some of the modern text books.

unite, and form water. In all cases of chemical combination bodies are united in definite proportions. Difference between mixture and combination as illustrated by comparison of air and water should be carefully explained.

Experiments.—Illustrate the characteristic properties of ice, water and steam. Show that equal volumes of hot and cold water do not counterbalance one another. Fill a flask to the bottom of the neck with cold water, and then heat to show expansion of the water. Show current by heating a large flask of water. To illustrate distillation distil water containing copper sulphate. Show Liebig's or other forms of condensers. Show the mode of determining the boiling point of a liquid. Show that the temperature remains constant and that on dissolving substances in water the boiling point is raised. To show the presence of hydrogen in water, pass steam through a red-hot iron tube filled with coarse iron turnings or nails. Note the change in the iron both in appearance and weight. Pass hydrogen over the copper blackened by heating in air, as shown in p. 53, and collect the water. Hence two substances in water, one the combustible gas that comes through the tube, the other a constituent of air. Collect the hydrogen over cold water in proof that it is not steam, also show that it burns. Explode a mixture of two volumes of hydrogen and one volume of oxygen. Plunge a burning taper into jar of hydrogen held mouth downwards, to show burning of the gas and extinction of the taper. Show by a balloon or soap bubbles, or inverted beaker glass suspended from a balance, that hydrogen is lighter than air. Condense the water formed by the burning of a jet of hydrogen.

SOLUTION.—Solvent properties of water. Disappearance of a solid in water by solution. Saturation. Effect of temperature on saturation. Crystallization. Filtration. Rain, spring, river, and pond waters, &c. Solid matter in different waters; how estimated. Sea water. Hard and soft waters. Solution of gases in water and other liquids.

Experiments.—Suspend a piece of white sugar, on a tray of perforated zinc or wire gauze, by a thread in a glass vessel containing water. Dissolve salt in water. Show on a balance that sugar or salt and water when separate and when dissolved weigh the same. Show that salt is obtained from the solution by evaporation. Saturate water with nitre, and show that the solubility is increased by increase of temperature. Determine the solubility by evaporating to dryness equal quantities of a boiling solution and a cold solution and weighing the residue. Demonstrate the formation of crystals. Illustrate the removal of substances in suspension, and the non-removal of substances in solution by adding water to a mixture of oxide of iron and common salt, and then filtering. Show by evaporation the solid matter dissolved in a sample of pump, or river, or spring water, and explain the method for its quantitative determination. Show the like solvent action with other liquids, as camphor or shellac in alcohol, and fat or caoutchouc in ether Heat ordinary water and collect the expelled air.

CARBON.—Charcoal, graphite or black lead, and diamond. When wood, sugar, meat, or bread are heated carbon remains. (See Carbon Compounds, to be studied later, p. 58) Charcoal not changed in the air at ordinary temperatures. Combination of carbon with the oxygen of the air at a red heat. Chemical combination of carbon and oxygen is attended by the evolution of a definite amount of heat expressed by amount of water it will heat. Combustion. The properties of carbon dioxide. Water dissolves carbon dioxide at ordinary temperatures. Action of carbon dioxide on lime-water. No animal can live in this gas. One hundred parts of carbon dioxide are composed of 27·27 parts of carbon and 72·73 parts of oxygen. Carbon dioxide obtained from marble, limestone, oyster-shells, chalk, &c. Charcoal fire. Coal composed of carbon, hydrogen, and little oxygen, &c.; its burning is the result of the carbon and the hydrogen combining with oxygen. Whenever oil, tallow, or coal gas is burnt carbo-

dioxide and oxide of hydrogen (water) are formed. Respiration produces similar changes. In expired air the same products arise as from the burning of the food, and there is the same evolution of heat. Carbon a constituent of all animal and vegetable bodies.

Experiments.—Specimens of charcoal. Make charcoal by heating wood in a test-tube provided with a cork and delivery tube. The blacklead of a pencil as a specimen of graphite. Show that acids and alkalies do not change charcoal, but that when heated it soon burns away, and only ash is left. Take a small piece of charcoal in a glass tube, pass air over it into lime water, and show no change takes place until the charcoal is made red hot; as the charcoal disappears the lime water becomes milky. Prepare carbonic acid gas by acting on marble with dilute acid. Show by means of the balance, or by soap bubbles, or by passing it from one vessel to another, that carbon dioxide is heavier than air, that it acts on lime water, that a burning candle is extinguished in it. Its solubility in water shown by agitating a tube of the gas over the water. Collect all the gas given off from a small piece of marble weighing 1 or 2 grammes. Show by collecting in inverted beaker the products of combustion of a candle, of a lamp, and of a gas flame, and adding lime water, that carbon dioxide is given off. Show also by means of lime water that respired air contains this gas.

FLAMES.—Candle-flame, gas-flame, air-gas flame, petroleum-flame. Incandescence. Incandescent gas-flame. Incandescent electric lamp.

Experiments.—Dissect candle-flame. Show similarity of flames from gas-jet and petroleum lamp. Demonstrate deposition of carbon from all these flames. Explain construction and action of Bunsen-burner and its flame, and show absence of free carbon. Show blow pipe flame and demonstrate areas of oxidation and reduction.

Show incandescence of asbestos in Bunsen flame and, if possible, of lime in oxyhydrogen flame. Explain construction and mode of action of incandescent gas burner and of incandescent electric lamp.

ACIDS are bodies which have sour taste, turn blue litmus red, and liberate carbon dioxide when added to solution of sodium carbonate. Sulphuric acid has these properties. Nitric acid and hydrochloric or muriatic acid have strong acid properties like sulphuric acid. All act on litmus, &c., in same way; all can be neutralised by potash forming potassium sulphate, or nitrate, or chloride. The compound formed by the interaction of an acid and an alkali is called a salt. Water is always formed at the same time. All three acids are colourless liquids, but beside the properties possessed by all acids, each acid has properties which belong to it alone. Nitric acid attacks most metals. Poured on copper the metal is dissolved and red fumes are formed. Hydrochloric acid dissolves copper very slowly, is not so heavy as sulphuric acid, and when mixed with manganese dioxide and warmed a yellow irrespirable gas, known as chlorine, is given off.

Experiments.—Samples of nitric and hydrochloric acids. Show that both have all the properties belonging to acids, and that by neutralising them with potash and soda respectively nitre and common salt can be made. Show the action of nitric acid on copper, tin foil, &c. Show that it has no action on platinum or on gold. Copper placed in hydrochloric acid diluted with water not attacked, but if mixed with manganese dioxide and warmed, chlorine is given off. Demonstrate the colour, bleaching power, and other characteristic properties of chlorine.

ALKALIES.—Are bodies which turn red litmus blue; have soapy taste and absorb carbon dioxide. If potash, soda, or solution of ammonia be added gradually to sulphuric acid the properties of both alkali and acid gradually disappear, and at last a liquid is obtained that has no action on litmus. This result of this combination of acid and alkali is potassium sulphate, sodium sulphate or ammonium sulphate.

Experiments.—Show that solutions of potash, soda, and ammonia turn reddened litmus blue, and that when a tube containing carbon dioxide is inverted in any of these solutions the gas is absorbed. Add gradually to dilute sulphuric acid one of these bodies, and see that the acid character of the dilute sulphuric acid disappears. Neutralise exactly sulphuric acid with potash, then evaporate and crystallise out the salt formed.

AMMONIA.—A gas with a very pungent smell. Solution in water. One volume of water dissolves 800 volumes of ammonia. This liquid has the pungent smell of the gas, and it can neutralise the strongest acids. Formation of ammonium chloride or sal ammoniac by ammonia with hydrochloric acid. Ammonium chloride a white solid, soluble in water, with no smell of ammonia. The effect of boiling a solution of ammonium chloride with lime or potash. Ammonia is composed of 82·3 parts of nitrogen and 17·7 parts of hydrogen. The pungent odour of smelling salts is due to ammonia. Animal matters, such as horn, dried flesh, glue, cheese, isinglass, heated strongly with lime, yield ammonia. The formation of ammonia in large quantities by heating coal to make coal gas. Production of ammonia when animal matters containing nitrogen putrefy.

Experiments.—Prepare ammonia by treating ammonium chloride with an equal weight of slaked lime and enough water to make the whole into a thick mud: and demonstrate its smell, its action on red litmus, and its great solubility in water. The gas passed into water, properties of the solution. Volatility of ammonia shown by the liquid leaving no residue on evaporation. Show that ammonium chloride is formed by neutralising a solution of ammonia with hydrochloric acid, and is obtained as a solid on evaporation, and that on further heating it is volatilised. Heat coal in a coarse powder in a test-tube provided with a cork and delivery tube, and show that the liquid obtained is very alkaline. Show the formation of ammonia by the addition of potash and lime to a solution of ammonium chloride.

LIME AND CLAY.—Limestone, marble, oyster-shells, and chalk all consist of calcium carbonate. When these are strongly heated, especially in a current of air, carbon dioxide is evolved and lime is left. Lime is the oxide of the metal calcium. Action of water on lime. Use of lime in making mortar. Lime slightly soluble in water. On blowing carbon dioxide into a clear solution of lime (lime-water), liquid becomes turbid owing to combination of carbon dioxide and lime to form chalk. Same effect on breathing through lime-water. Other important salts of lime are gypsum, plaster of Paris (sulphate of lime) and phosphate of lime, which latter exists largely in bone. Clay is a combination of a body called silica, which is the chief constituent of sand and flint, with the oxide of a metal known as aluminium, so called because it exists also in alum. Glass is a compound of silica with lime and an alkali, potash or soda. Varieties of clay; their use in manufacture of bricks and pots. The metal contained in clay (aluminium), a white body with a brilliant lustre, 2½ times as heavy as water; may be rolled out into thin sheets and drawn into fine wire. Not oxidised at ordinary temperatures in the air.

Experiments.—Samples of limestone, marble, oyster shells. Show that these substances effervesce with dilute hydrochloric acid, and that a gas carbon dioxide is evolved. Heat a piece of limestone or marble to redness in a fire, and show that after heating it no longer gives carbon dioxide on treatment with an acid. Describe process of lime-burning. Properties of lime as distinguished from limestone. Show that a piece of moistened red litmus paper pressed against limestone is not affected, but that when pressed against lime it is turned blue. Show slaking of lime; draw attention to heat evolved. No such result on treating limestone with water. Show that lime is soluble in water whereas limestone is not. Add carbon dioxide to the solution of

lime, and show by experiments that white powder thus formed is identical in chemical composition with limestone, and hence that limestone is a compound of carbon dioxide and lime. Show plasticity of clay and exhibit one or two specimens of ware before being baked. Show that a vessel of kneaded or "puddled" clay will hold water. Explain chemical nature of clay, and show specimens of silica and alumina. Show alum and demonstrate that alumina is contained in it by heating ammonia alum. Show specimen of aluminium and by burning the metal in oxygen show the formation of alumina.

METALS, INTRODUCTORY.—About 70 different elementary substances known. All the common metals are elements. For instance, iron, lead, copper, zinc, mercury, silver, gold, tin, are elements. All combine with oxygen to form oxides, with chlorine to form chlorides, and with sulphur to form sulphides. Metals combine with one another to form alloys, for example, brass, bronze, gold and silver coins, pewter, solder. Alloys which contain mercury are called amalgams.

Experiment.—Specimens of metallic and non-metallic elements and of oxides and sulphides should be exhibited and simple experiments practised with the object of demonstrating the relative density of some of the common metals, and the crystalline forms of a few common mineral oxides and sulphides, such as galena, magnetite, specular iron, &c.

LEAD.—Its colour; a fresh surface bright, but soon tarnishes in the air. Lead is 11½ times as heavy as water. Can be beaten or rolled into thin sheet or drawn into wire. Melts at temperature 633° F. or 335° C. Its combination when liquid with oxygen. Formation of lead oxide. The oxide has entirely different properties from lead. Removal of the oxygen when heated with carbon and the formation of metallic lead.

IRON.—Three kinds of iron; wrought iron, cast iron, and steel. Wrought iron nearly pure and used if the body is to be formed by hammering. Cast iron contains most carbon. Steel used for cutting instruments; can be made into magnet; can be "annealed." Solubility of all three forms of iron in sulphuric, nitric, and in hydrochloric acids, and the formation of iron sulphate, nitrate, and chloride. Melting point of iron is at much higher temperature than that of lead. Comparison of the weight of iron with that of water. Its colour. The ready action of moist air on it. Formation of rust. Oxidation by heating. The action of steam on iron when red hot. Oxide of iron heated with hydrogen or with carbon parts with its oxygen, and iron is left Oxide of iron found in the earth. Hæmatite. Clay iron stone, a carbonate of iron mixed with clay used as a source of iron. By heating the ore oxide of iron is obtained. Removal of the oxygen by heating it to a very high temperature with carbon. Formation of slag from clay and lime.

Experiments.—Specimens of the different kinds of iron, wrought iron, cast iron, and steel. Dissolve grey cast iron in hydrochloric acid diluted with equal volume of water, show carbon which remains, filter and evaporate the liquid to show the chloride of iron formed. Heat iron wire by the blowpipe to show the high temperature required to fuse it. Iron acted on by air and moisture to show its rusting. Heat iron oxide in a tube and pass hydrogen over it to show formation of water and metallic iron. Show specimens of iron ores, clay iron stone, hæmatite, magnetic iron ore, and slag.

COPPER.—Its colour. Does not rust in air at ordinary temperatures. When heated in air becomes black, owing to the formation of an oxide. Oxide heated in hydrogen gas yields up its oxygen, water is formed, and the red-coloured copper is obtained. Action of acids on copper. With dilute nitric acid evolves a colourless gas, which turns red in contact with the air, and the metal dissolves, forming a blue solution of copper nitrate. The substance formed when copper oxide dissolves

in dilute sulphuric acid is copper sulphate. When crystallised from wa[illegible]er has a fine blue colour, and known as blue vitriol. Deposition of metal[illegible]ic copper when iron or zinc is placed in a solution of the sulphate. Use [illegible] of copper in alloys. A penny composed of 95 parts of copper, 4 parts of ti[illegible]n, and one part of zinc. Bell metal and gun metal contain copper and tin.

Experiments.—Show specimens of copper in bar, sheet, and wir[illegible]re. Point out characteristic colour of metal. Show action of nitr[illegible]ric acid upon copper. Exhibit specimen of copper sulphate (blue vitriol[illegible]l). Show that on placing a knife blade in a solution of copper sulphat[illegible]te metallic copper is deposited on the steel. Show various alloys o[illegible] of copper; bell-metal, brass, gunmetal, a penny-piece.

SODIUM.—Common salt contains a metal combined with chlorine known[illegible]wn as sodium. 100 parts of common salt contain 39·3 parts of sodium an[illegible]nd 60·7 parts of chlorine. Carbonate of soda (washing soda) contains sodium[illegible]m. Sodium one of the lightest solids known. Swims on the surface of wate[illegible]er and decomposes that liquid with evolution of hydrogen and formation o[illegible]f the alkali soda. Preservation of sodium from action of air by being kep[illegible]p in some liquid lighter than water and free from oxygen.

Experiments.—Samples of common salt and rock salt; also washing[illegible]g soda and bicarbonate of soda. Experiments showing that chlorine[illegible] is a constituent of common salt. Show that washing soda and sodium[illegible] bicarbonate evolve carbon dioxide on treatment with an acid. Exhibit[illegible] specimen of sodium. Show that it can be cut with a knife, and [illegible] exhibits metallic lustre, but that it quickly tarnishes in the air. Show[illegible] that sodium is lighter than water and decomposes that liquid with[illegible] evolution of gas (hydrogen). Collect hydrogen from water; this is done[illegible] most safely by cutting off half-inch lengths of narrow composition[illegible] pipe, closing one end of each by pinching and stuffing a small piece[illegible] of sodium into the open end. Tubes thus charged can be thrown one[illegible] at a time into water, and the gas collected in a small jar filled with[illegible] water and inverted over them.

CARBON COMPOUNDS.—Large numbers of substances are met with in plants and animals which are not found in the earth. Most of these bodies contain carbon. The other elements united with the carbon are hydrogen, oxygen, nitrogen; some bodies are composed of all these elements; others of only two of them. Many of these bodies when heated leave a black residue of carbon; when this is more strongly heated in the air it burns away. The great number of these carbon compounds, and the great difference in their properties. Some are acids, *e.g.*, vinegar (acetic acid), and tartaric acid. Some are salts, *e.g.*, fats, tallow, butter. Some are neutral bodies, *e.g.*, sugar, starch, spirit.

Experiment.—Show that on heating any ordinary vegetable or animal substance carbon is left behind, and that all on being burnt in oxygen give carbon dioxide, the formation of which proves the presence of carbon.

ACETIC ACID.—One form of dilute acetic acid is known as vinegar. Formation of acetic acid when beer or wine exposed to the air becomes sour. The spirit present combines with oxygen of the air and forms acetic acid. The presence of a kind of fungus called mycoderma aceti necessary to cause this oxidation. Large amount of vinegar is made from poor kinds of wine and beer. Action of vinegar on blue litmus, and on sodium carbonate. Acetic acid is made by heating wood in a retort; tar and a watery liquid containing acetic acid distil over. The pure acid has a very pungent smell, and has all the properties which are characteristic of acids. It is composed of carbon, hydrogen, and oxygen in the proportion of 40·0 parts of carbon, 6·7 parts of hydrogen, and 53·3 parts of oxygen. It is, like sulphuric acid, neutralised by alkalies. Iron put into it is slowly dissolved, hydrogen being given off. Oxide of lead dissolves in it, forming a salt, and if the clear solution be evaporated a white crystalline compound called "sugar of lead," is formed, which is lead acetate.

Experiments.—Show that vinegar has the properties of an acid, and that a salt is formed on neutralising it. Show a specimen of the commercial acetic acid, and point out its colourless appearance and strong smell and acid reaction. Show that iron is acted on and dissolved by acetic acid. Make sugar of lead by dissolving lead oxide in acetic acid, and crystallise out the salt. Point out disappearance of the pungent odour of the acid on neutralisation by potash or soda. Demonstrate the formation of the acid on addition of sulphuric acid to sodium acetate, and show that it can be separated from the liquid by distillation.

AT AND OILS.—Are neutral bodies having a constitution similar to that salt. All common fats and oils yield glycerine which corresponds to base, but the acid they yield varies in different cases. They are all luble in water. Oils are liquid ; fats are solid. Many of the oils are ined from vegetables, either from the seed or fruit. Most of the fats from animals. Melting of tallow (fat of the ox, sheep, &c.) put in boil- water. Its lightness as compared with water. If fat be boiled with lution of caustic potash, the liquid becomes slightly milky, and nearly whole of the fat gradually dissolves with formation of potassium rate and glycerine. If to this solution hydrochloric acid is added, assium chloride is formed and stearic acid, which, as it cannot olve in water, separates out. Stearic acid dissolves in alcohol and in r, and separates out in crystals on evaporation. Used in making candles, is better than tallow because it melts at a higher temperature. Tallow illed with steam of temperature 600° F. (superheated steam) yields ric acid and glycerine, which separate on cooling. All oils and fats are mposed by potash in the same way as tallow.

Experiments.—Tie beef or mutton fat up in a muslin bag, and melt in boiling water to separate the fat from membrane. Show that fat is insoluble in water, that it floats on water, and melts at a temperature below boiling water. Show that oil has very similar properties to melted fat. Boil oil or fat with caustic potash. Prepare a solution of potassium stearate, and precipitate stearic acid from it by the addition of hydrochloric acid. Show the solubility of the acid in alcohol and ether, and the insolubility of the lime salt of stearic acid.

Specimen of glycerine. Demonstrate its solubility in water, its sweet taste, its combustibility when heated.

AP.—By boiling fat with caustic soda sodium stearate is formed. On ing salt or excess of soda to the liquid the sodium stearate, which is soap, rates out as a curdy mass. Soft soap is potassium stearate. Action of in washing. Action of soap on hard and on soft waters.

Experiment.—Shake distilled water up in bottle with soap. Show action of solutions of salts and acids on the solution. Add soap solution to distilled water, also to common water, and explain the difference of action. Show the production of fatty acid from soap by adding hydrochloric acid to a solution of soap.

UGAR.—Exists in the juice of many plants. Is obtained from the sugar e and from beet root. When pure it is white, crystalline, sweet, and soluble in water. Sugar candy. If strongly heated with very little er is converted into non-crystalline "barley sugar." Does not combine acids, but even a very little acid boiled for a time with a solution of ar changes it to a mixture of two kinds of sugar. The several different ls of sugar, *e.g.*, the solid part of honey is a sugar which differs from the ar in the sugar cane ; the same found in all sweet fruits and is called e sugar or glucose. Grape sugar not so sweet nor so soluble as cane ar.

Experiment.—Specimens of ordinary white and brown sugar ; also sugar candy and barley sugar. Show its great solubility in water ; also that its solution is neutral. Heat white sugar and draw attention to the peculiar odour of the products of decomposition, and show that on further heating it leaves a residue of carbon. Wash honey with spirit, and show that the residue is a kind of sugar, but that it is not so sweet as ordinary sugar and not so soluble.

STARCH.—A neutral substance, composed of carbon, hydrogen, and oxygen. Peculiar structure; not crystalline. Is found in all parts of a plant. Is obtained from wheat, rice, potatoes, arrowroot, &c. Starch in its ordinary condition insoluble in cold water. When starch powder is boiled with water the starch is partially dissolved. Strong solutions form a jelly when cold. Starch recognised by its forming a blue compound with iodine. Undergoes no change in the air at ordinary temperatures; if heated to about 300° F., it becomes slightly discoloured, and is changed into a soluble substance, known as British gum (dextrin). If small amount of nitric or hydrochloric acid be added to the starch, this change is more rapid. Glucose made commercially by heating a solution of starch with acids. Extract of malt also changes starch into dextrin and a sugar (maltose) resembling grape sugar. Starch as a food.

Experiment.—Specimen of starch, show by the microscope its peculiar structure and absence of crystalline form. Demonstrate that it does not dissolve in cold water, but on boiling some does dissolve. Show that starch both solid and in solution gives a blue colour when iodine is added to it. Moisten starch with very dilute hydrochloric acid, and heat to convert it into dextrin. Show that dextrin is soluble in water and does not give a blue compound with iodine.

GLUTEN AND ALBUMEN.—If flour is tied up in a muslin bag and well kneaded in a basin of water, the water becomes milky, and on standing starch sinks to the bottom. All the starch in the flour can be thus removed, and then a sticky substance remains in the bag called gluten, a form of vegetable proteid. Flour contains about 70 per cent. starch and 10 per cent. gluten. Gluten contains nitrogen, starch does not. These bodies represent two most important constituents of food. The gluten exposed to the air soon decomposes and putrefies. White of egg or albumen, a form of animal proteid, like gluten, contains nitrogen. Is representative of the principal constituent of animal food, "coagulates" or "clots" when gently heated, and is then no longer soluble in water.

Experiments.—Make up some flour into dough, tie it up in a piece of muslin and knead it for some time in a basin of water; the starch comes through and will settle to the bottom of the vessel and can be collected and examined; the gluten remains in the bag. Heat some flour in a porcelain dish first in an oven where it turns brown, then more strongly over a flame. It blackens and yields a smell somewhat like burnt sugar while a mass of carbon remains. Place a lump of this on a piece of platinum foil and heat till the carbon is burnt off. A small white ash consisting chiefly of potassium phosphate remains.

Separate the white of an egg. Thoroughly mix it by agitation with about an equal volume of water. Evaporate a small portion of the solution to dryness in a capsule and heat strongly, and observe the separation of carbon. Mix another portion into a thick paste with lime and heat gradually. Notice again the charring and smell of ammonia, and the change of colour of moistened red litmus paper to blue when held just above the heated mass. Repeat this experiment with gluten, and notice the same result. Heat some of the albumen solution in a test-tube, and observe the "clotting" or "coagulation."

SPIRIT.—Alcohol, spirits of wine. A colourless, light liquid. Neutral to test papers. Has pleasant odour, boils at 173° F. Burns with a flame, which gives very little light, without leaving any black residue of carbon. Sugar, camphor, and many other substances, but few salts, dissolve in it. It is the intoxicating principle in wines and spirits. In beer there is 3 to 5 per cent. of alcohol. In light wines about 8 per cent. In spirits 60 to 75 per cent. The different flavours of wines and spirits depend on very small quantities of other ingredients. Alcohol mixes with water in all proportions.

Alcohol obtained from grape sugar. Fermentation—grape sugar converted into alcohol and carbon dioxide by presence of some ferment such

yeast. Cane sugar on the addition of yeast is first converted into grape sugar, then into alcohol and carbon dioxide. Use of yeast in brewing. Yeast not necessary for making wine as there is already a ferment in expressed juice of grape.

Experiment.—Show that alcohol is a neutral liquid dissolving in water, that it burns with nearly colourless flame, and leaves no residue of carbon. Show that it can be made to boil at much lower temperature than water by placing test-tube of it in hot water. Distil beer and collect the mixture of alcohol and water which comes over; add quicklime to this. Allow it to stand some hours and distil again. Show that this is much stronger, catches fire readily, and tastes more burning. Make a solution of common sugar in a large flask; add yeast, and fit a cork with a bent tube to the flask. Let the tube dip into lime water. Place it in a warm place, and when the action is over show that spirit has been formed by distilling the liquid and collecting the portion coming over first.

All the substances and experiments mentioned above should be shown to the class. This does not preclude such other experiments and illustrations as may suggest themselves to the teacher.

STAGE 2.

In addition to the subjects of the syllabus of Stage 1 (p. 47) students presenting themselves for examination in Stage 2 will be assumed to have received instruction in the following subjects:—

The experimental methods by which the composition of the following compounds has been accurately determined:—water, atmospheric air, hydrochloric acid, ammonia, the gaseous oxides of nitrogen, the oxides of carbon, sulphuretted hydrogen.

Laws of gaseous combination of elements and compounds. Reduction of gaseous volumes to standard pressure and temperature. Calculation of quantities by volume and by weight.

Atoms and molecules, atomic and molecular weights. Law of Avogadro. Atomic and molecular formulæ and equations. Specific heat and atomic heat of the elements. Atomic value or valency of the elements. Phenomena of dissociation. Classification of the elements.

WATER.—Causes of permanent and temporary hardness in. Modes of softening. Suitability for domestic purposes. Determination of composition of water by weight and by volume.

HYDROGEN DIOXIDE.—Its preparation and properties.

OZONE.—Production, properties and constitution. Occurrence in nature.

ATMOSPHERIC AIR.—Mode of ascertaining exact composition of. Carbon dioxide, amount contained in, and determination of. Aqueous vapour, determination of.

CHLORINE.—Theory of bleaching. Hypochlorites, chlorates and perchlorates, production, properties and characteristic reactions.

BROMINE, and hydrobromic acid.

IODINE, and hydriodic acid; iodates and periodates.

FLUORINE.—Hydrofluoric acid.

Comparison with one another of chlorine, bromine and iodine, and of their more important compounds.

PHOSPHORUS, its sources and its allotropic modifications; its hydrides, chlorides, and oxides. Phosphoric acids and the phosphates. Hypophosphorous and phosphorous acids and their salts.

ARSENIC, and its hydrides, chlorides, and oxides. Arsenious, and arsenic acids. Arsenites and arsenates. Detection of arsenic.

ANTIMONY and BISMUTH.—Hydride, chloride, and oxides of antimony, chloride, oxides and salts of bismuth, to be studied chiefly with the object of showing the relation of these two elements to the members of the phosphorus group.

BORON. Boron trioxide. Boric acid.

SILICON, and silica. Silicic acid. Silicon hydride, silicon fluoride. Names and formulæ of a few of the more important mineral silicates.

CARBON.—The preparation, properties, and chief reactions of a few carbon compounds chosen with the object of illustrating the processes of substitution, of oxidation and reduction, the meaning of constitutional formulæ and evidence upon which they are constructed; also the characters of homologous series. The following compounds should be studied: Marsh gas, and the homologous paraffins treated as a series, ethylene, acetylene, methyl and ethyl alcohols, formic acid, acetic acid, and their relations to one another.

Chief methods for the isolation and characteristic properties of the following metals, and the composition and properties of their more important compounds. Potassium, sodium, ammonium, silver, mercury, copper, zinc, magnesium, barium, strontium, calcium, tin, aluminium, platinum, lead, chromium, manganese, iron.

The processes of formation and crystallisation of the chief salts of these metals should be practically demonstrated, and specimens should be prepared by the students.

STAGE 3.

SECTION I.

Candidates will be examined more fully upon the subjects included in the syllabus for Stage 2, with the addition of the following:—

Cyanogen, hydrocyanic acid and cyanides. Ferrocyanides, ferricyanides, and sulphocyanides (thio-cyanates).

Classification of the elements. Relations between atomic weight and specific heat. Methods of determining atomic weights.

SECTION II.

Four questions, out of a total of eight to be attempted, may be answered on subjects included in this section. All candidates, however, will be required to satisfy the Examiners in at least four questions taken from Section I.

Manufacturing processes for the production of—

Oxygen.
Chlorine, bromine, iodine.
Bleaching powder.
Sulphuric acid.
Hydrochloric acid.
Nitric acid.
Sodium carbonate and caustic soda.
Lime.
White lead.
Coal gas.
Iron and steel.
Copper.
Lead.
Mercury.
Silver and gold.
Zinc.
Aluminium.
Sodium.

These questions are intended for candidates who are, or have been, engaged in industrial occupations, and a certain amount of technical knowledge will be expected.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.) of either Inorganic Chemistry or Organic Chemistry.

Such a general knowledge will be required of the facts and principles of Chemistry as will enable the candidate to discuss critically theories relating to any part of the Science, including the general principles of Physical Chemistry and the more important of the special methods used in the investigation of carbon compounds, and conclusions drawn from their study. A knowledge will also be expected of the outlines of the history of Chemistry from the time of Boyle to the present day.

SUBJECT Xp.—INORGANIC CHEMISTRY, PRACTICAL.

COMPULSORY EXERCISES MAY BE SET AT THE EXAMINATION.

STAGE 1.

Exercises may be selected from any of the following divisions of experimental work :—

A.—Carrying out experiments for which printed instructions will be given in the paper, *e.g.*, the observation of the effects of heat or of water, or acids, &c., upon the materials supplied. If a gas is evolved, the candidate may be required to determine what it is. [Such a gas will always be one of those referred to under Subject X., Stage 1, of which the properties have been demonstrated in the lectures.]

B.—Recognition of materials which have been exhibited upon the lecture table, and the properties of which have been demonstrated, *e.g.*, sulphur, iodine, charcoal, manganese dioxide, potassium chlorate, nitre, sal-ammoniac, &c.

C.—Quantitative experiments of a simple kind, *e.g.*, a metal or a salt may be supplied to be weighed, dissolved in acid, and the amount of evolved gas measured at the temperature of the laboratory. Or the carbon dioxide in a carbonate may be estimated by solution in an acid, and observation of the loss of weight. Or determination of the weight of one metal, such as silver, which can be displaced by another, such as magnesium. Or experiments on the neutralisation of acids or alkalies.

STAGE 2.

The examination will consist of two parts :—

I. A short written examination of about four questions with the object of testing the candidate's knowledge of the theory of ordinary methods of qualitative analysis and the preparation of such bodies as are enumerated in the Syllabus for Stage 2 of Subject X. (Theoretical).

II. A practical examination in Experimental Chemistry.

A.—One or two substances may be given for qualitative analysis, each containing not more than four salt radicles, positive or negative, selected from the following list: silver, lead, mercury, copper, bismuth, cadmium, tin, arsenic, antimony, iron, manganese, aluminium, chromium, zinc, cobalt, nickel, calcium, strontium, barium, magnesium, potassium, sodium, ammonium, oxides, hydroxides, chlorides, bromides, iodides, fluorides, sulphides, sulphites, sulphates, chromates, carbonates, phosphates, arsenates, borates, silicates, nitrates, nitrites, chlorates, permanganates.

There might, therefore, be four metals in the form of oxide, or three metals in the form of the same salt, or two simple salts or one metal in the form of three salts.

B.—One substance may be given to be tested quantitatively by means of a volumetric solution to be provided.

C.—Candidates may also be required to carry out experiments with the above-mentioned or other materials with the object of testing their knowledge of the laws and methods of chemistry not included among the ordinary methods of analysis. For these, instructions will be given in the paper.

Four hours will be allowed for the examination in practical analysis, and one hour for the written examination.

NOTE.—Candidates will not be allowed to communicate with one another during the examination but the use of notes or text-books of analysis will be permitted in the Laboratory work.

STAGE 3.

The examination will occupy one day of eight hours.

Subjects.—1. Qualitative analysis, in which substances will be given which must be examined for the whole of the radicles contained ir the list given above for Stage 2, Practical.

2. Gravimetric and volumetric analysis.

3. Preparation of pure substances or carrying out other well recognised operations.

The gravimetric analysis should include exercises in the determination of the following metals: silver, lead, mercury, copper, tin, iron, manganese, aluminium, chromium, zinc, cobalt, nickel, calcium, barium, magnesium, potassium, sodium, ammonium; and of the following acids, hydrochloric, hydrobromic, hydriodic, sulphuric, carbonic, phosphoric, nitric, and hydrosulphuric.

The volumetric analysis should include exercises in the ordinary methods of acidimetry and alkalimetry; and use of standard solutions of potassium permanganate or bichromate, iodine, sodium thiosulphate, and silver nitrate.

For this Examination the use of books will be allowed.

NOTE.—Candidates will be admitted to this Examination in the same year in which they take the Stage 3 Examination in Theoretical Chemistry. They will, however, be at liberty to present themselves for these examinations in different years.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 of either Practical Inorganic Chemistry or Practical Organic Chemistry.

The examination will occupy three or more days, and will be conducted in London.

Analytical work will include gas-analysis, and analysis of minerals and commercial metals Analysis of carbon compounds by combustion. Separations by fractional distillation or otherwise. Vapour density determinations. Preparation of compounds (including "Organic" compounds) or elements in a state of purity.

Candidates will not be allowed to communicate with one another during the examination, but they will be allowed the use of note-books or any works of reference they may choose to bring with them.

NOTE.—Candidates will be admitted to this examination in the same year in which they take the examination in Honours, Theoretical Chemistry; or they may present themselves for the two examinations in different years. It should be understood that no candidate can obtain Honours who is not prepared to carry out any observations or experiments commonly practised in the best chemical laboratories.

In lieu of part of the above examination a thesis upon any subject involving experimental work done by the candidate, and properly attested, will be accepted.

Candidates for Honours in Chemistry are advised to present themselves for the successive examinations in the following order:—

Inorganic Chemistry, Theoretical, Stage 3.
" " Practical, Stage 3.
Organic Chemistry, Theoretical, Stage 3.
" " Practical, Stage 3.
Theoretical Chemistry, Honours.
Practical " Honours.

The intervals between the successive stages will depend upon circumstances, but the standard for success in Stage 3 is such that an industrious evening student who has obtained a First Class in Stage 2 may expect to pass the Examination after two further years of study in an Evening Class meeting once a week during the Winter and Spring Sessions.

LABORATORY FOR PRACTICAL INORGANIC CHEMISTRY.

Where payments are to be claimed in Practical Chemistry the school must be provided with a laboratory which has been passed by the Inspector as satisfactory.

The laboratory must be properly fitted and equipped and meet all sanitary requirements, and will be expected to comply generally with the following conditions. Each student should have a working space of at least 3 feet 6 inches by 2 feet 3 inches on the bench-table. Shelves for reagents, &c., should be fitted above, and drawers and cupboards for apparatus, &c., below the table. Gas should be laid on to each student's bench, and there should be a water tap with an earthenware or lead-lined sink for every two students, if possible. Closets should be provided for evaporation of substances evolving noxious fumes and for sulphuretted hydrogen work. These closets should be ventilated by flues carried up in the wall of the building, so as to ensure the extraction of the fumes. Niches with flues should also be provided for combustion furnaces.

The laboratory and apparatus must be kept clean, tidy, and in good order—failing which payments may be reduced or withheld. It must be set apart entirely for the study of Practical Chemistry; it may not be used as a class-room for any other subjects.

Each bench must be furnished with sufficient apparatus and be always kept in good working order.

SUBJECT XI.—ORGANIC CHEMISTRY, THEORETICAL.

CHEMISTRY OF CARBON COMPOUNDS.

COMPULSORY QUESTIONS MAY BE SET AT THE EXAMINATION.

STAGE 1.

Peculiarities of the element Carbon which render necessary the separate study of its compounds. Qualitative recognition of carbon, hydrogen, oxygen, nitrogen, the halogens, sulphur and phosphorus in carbon compounds. Methods for their quantitative estimation. Calculation of percentage composition from the results of analysis and deduction of empirical formulæ. Determination of molecular weights.

Hydrocarbons or Compounds of Carbon and Hydrogen.

(1.) Paraffins or $C_n H_{2n+2}$ Series. Marsh gas or methane, ethane, propane, butane, pentane.

Modes of occurrence, preparation and general characters of paraffins. Homology and isomerism.

(2.) Olefine, or $C_n H_{2n}$ Series. Ethylene, propylene, butylene, pentylene.

Modes of occurrence, preparation and general characters of the olefines. Distinction between saturated and unsaturated hydrocarbons.

(3.) Acetylene or Ethine Series $C_n H_{2n-2}$.

Preparation and distinctive characters of acetylene.

Derivatives of the Hydrocarbons.

(1.) Paraffins.—Haloid derivatives; methyl chloride, methylene chloride, chloroform, carbon tetrachloride, iodoform, ethyl chloride, bromide and iodide, ethylene dichloride and dibromide.

Alcohols.—Methyl, ethyl, propyl, butyl, and amyl alcohols; primary, secondary and tertiary alcohols.

Methyl alcohol.—Destructive distillation of wood. Purification and properties of methyl alcohol.

Ethyl alcohol.—Modes of occurrence. Industrial preparation of spirituous liquids. Rectified, proof, and methylated spirits. Alcoholometry.

Preparation of pure alcohol, derivatives and chief reactions of alcohol, constitution of alcohol. Fusel oils. Properties of propyl, butyl, and amyl alcohols.

Ethereal Salts or Esters.—Ethyl acetate, ethyl sulphate, ethyl hydrogen, sulphate, ethyl sulphide, and mercaptan.

Ethers.—Manufacture of ethyl oxide.

Aldehydes.—General methods of preparation. Properties of formaldehyde and acetaldehyde.

Acids.—Series of fatty acids. General methods of preparation. Formic acid, occurrence, preparation, and properties. Acetic acid manufacture. Vinegar, chief acetates.

Discussion of the constitutions of acetic acid, propionic acid, normal and isobutyric acids. Palmitic and stearic acids. Nature of common fats, process of saponification. Hard and soft soaps.

Acetic anhydride and acetyl chloride, and their use as re-agents for the recognition of hydroxyl.

Ketones.—Preparation and properties of acetone, and methyl ethyl ketone.

Compounds of alcohol radicles, with nitrogen, phosphorus, arsenic, silicon, and the metals, especially zinc and mercury. Cacodyl and its chief derivatives. Preparation and properties of zinc ethyl.

Amines.—Preparation and properties of the primary, secondary, and tertiary ethylamines. Preparation and properties of methyl- and ethyl-ammonium salts.

Amides.—Distinguished from amines. Preparation and properties of acetamide.

Nitriles.—Preparation and properties of acetonitrile.

Amido Acids.—Glycine (glycocoll).

(2.) Olefines.—Haloid compounds and derivatives of olefines, especially ethylene dichloride, and dibromide.

Alcohols.—Preparation and properties of glycol, acids from glycol, glycollic and oxalic acids, succinic, malic and tartaric acids and citric acid. Their modes of occurrence, preparation and properties.

Synthesis of succinic, malic, and tartaric acids.

Lactic Acids.

Acrolein, acrylic acid. Oils of mustard and garlic. Preparation and characteristic reactions of allyl alcohol.

Glycerin, and its chlorhydrins and nitrate (nitro-glycerin).

Mannitol and the Carbohydrates.—Cane sugar, dextrose (glucose) and levulose (fructose), maltose, milk sugar. Their occurrence in nature, manufacture, properties and distinctive tests.

Starch and the dextrins. Cellulose and gun-cotton.

Cyanogen Compounds.—Synthetical formation of cyanides.

Manufacture and properties of potassium ferrocyanide and ferricyanide. Prussian blue.

Preparation of hydrocyanic acid, the cyanides of potassium, silver and mercury.

Preparation and properties of cyanogen.

Cyanic and cyanuric acids. Urea. Preparation, constitution, and quantitative estimation.

STAGE 2.

Division of the carbon compounds into—

(1.) The Fatty Division.
(2.) The Aromatic Division.

Constitutional differences between the two classes of compounds.

Examples of the production of closed chain compounds from compounds of the fatty division. Nomenclature and Notation.

Benzene.—Sources, preparation and properties. Constitution of benzene. Preparation and properties of its more important homologues, especially toluene, the three xylenes, and cymene.

Mono-derivatives of benzene, viz.:—chloro-, bromo-, and nitro- benzene and benzene-sulphonic acid, also dinitrobenzene and benzene-disulphonic acid. Preparation and chief properties. Isomeric monochlorotoluenes, benzyl chloride.

Phenol.—Sources, manufacture and properties; nitro-phenols including picric acid.

Aniline.—Sources, manufacture and properties. Preparation of aniline sulphate, and hydrochloride. Action of methyl iodide on aniline. Action of nitrous acid upon aniline in aqueous and in alcoholic solutions. Constitution of diazo-compounds, diazo-amido-compounds, and amido-azo-compounds.

Nitranilines.—Preparation and characters.

Toluidines, source, manufacture and chief properties. Preparation of magenta dye. Constitution of rosaniline and its methyl and phenyl derivatives.

Phenyl hydrazine.—Preparation, properties and uses as a re-agent.

Quinone.—Preparation and properties.

Catechol, resorcinol, and hydroquinone (quinol).—Preparation and properties.

Benzyl alcohol.—Production from toluene.

Benzaldehyd.—Production from bitter almonds and from toluene.

Amygdaline, an example of a glucoside.

Benzoic acid.—Sources, manufacture, and properties.

Hydroxybenzoic acids, especially salicylic acid.—Sources, manufacture, properties, and uses of salicylic acid.

Toluic acid and the phthalic acids.—Sources and relations of.

Naphthalene.—Sources, purification, and properties, and derivatives of naphthalene.

Preparation and properties of nitro-naphthalene, naphthalene sulphonic acids, and naphthols, naphthol yellow. Constitution of naphthalene.

Anthracene.—Sources, purification and properties. Constitution of anthracene. Anthraquinone, preparation and methods for its conversion into alizarin. Natural source and properties of alizarin.

STAGE 3.

Candidates will be required to show a knowledge of the chief groups of carbon compounds, both "fatty" and "aromatic," including the following—

Pyridine.—Sources, purification, and properties. Constitution of pyridine.

Quinolines.—Source and properties of the quinolines (quinoline and isoquinoline).

Alkaloids.—Their general characters. Sources, preparation, and properties of morphine, strychnine, quinine, cinchonine, coniine, piperine, and piperidine.

Methods of distinguishing primary, secondary and tertiary bases.

Uric Acid Group.—Theobromine, caffeine, and uric acid.

Candidates must also be familiar with the more important methods, chemical and physical, for determining constitution, including the principal cases of stereoiso-merism.

HONOURS.

The examination will be identical with the examination in Subject X. Theoretical (*see* p. 63).

SUBJECT XI*p*.—ORGANIC CHEMISTRY, PRACTICAL.

CHEMISTRY OF CARBON COMPOUNDS.

COMPULSORY QUESTIONS MAY BE SET AT THE EXAMINATION.

STAGE 1.

In the first course the practical knowledge of the candidate will be tested both by a written and practical examination :—

I.—In the written examination the candidate will be expected to be practically acquainted with, and will be questioned upon the preparation of compounds enumerated in the Stage 1 of Subject XI., and the methods of experimentally demonstrating their properties. These questions will, as much as possible, be so framed as to prevent answers being given by students who have obtained their information merely from books and oral instruction. Any student in this stage on whom it is intended to claim payments may be called on by the Inspector of the Board, when visiting the Laboratory, to repeat some of the experiments which he has had the opportunity of witnessing.

II.—For the practical examination the student will be required to make himself practically acquainted with the methods of detecting carbon hydrogen and nitrogen in carbon compounds, and the determination of melting and boiling points. He must also be acquainted with the re-actions of, and tests for, the following substances, and will be required to recognise in two or more powders soluble in water or dilute acid the following compounds : ethyl alcohol, glycerin, formic acid, acetic acid, oxalic acid, tartaric acid, citric acid, hydrocyanic acid, urea ; not more than two of them being present in any one solution. The results to be carefully written out, and the presence of each constituent to be confirmed by two or more re-actions.

No notes, books or analytical tables may be consulted during the examination.

Two and a quarter hours will be allowed for the examination in practical analysis and one hour for the written examination.

STAGE 2.

The examination will consist of two parts :—

I.—A short written examination with the object of testing the candidate's knowledge both of the principles of the analytical processes and the methods of preparing and demonstrating the properties of such bodies as are enumerated in Stage 2 of Subject XI., Theoretical.

II.—For the practical examination, the student will be required to be familiar with the methods of detecting carbon, hydrogen, nitrogen, sulphur, chlorine, bromine and iodine in carbon compounds, the determination of melting and boiling points. He will also be required to examine qualitatively mixtures each containing not more than two organic compounds.

The substances for analysis may contain the following constituents :—Hydrocyanic acid, formic acid, benzoic acid, oxalic acid, acetic acid, tartaric acid, citric acid, salicylic acid, cane sugar, glucose, starch, methyl and ethyl alcohols, glycerin, aniline, phenol, morphine, and urea.

He may also be required to prepare specimens of familiar compounds from materials supplied.

The use of note-books or books of reference is permitted in the practical part of the examination.

The remarks with respect to inspection made in Stage 1 apply also to this stage.

Three and a quarter hours will be allowed for the examination in practical analysis and one hour for the written examination.

STAGE 3.

The examination will occupy one day of eight hours, and will include the recognition of single substances in the solid state or in solution, by tests, the detection of the elements carbon, hydrogen, nitrogen, the halogens, sulphur or phosphorus in carbon compounds, the preparation of specimens, and easy quantitative work. The use of text books is allowed.

HONOURS.

The examination will be identical with the examination in Subject Xp. (*see* p. 64).

Laboratory for Practical Organic Chemistry.

A Laboratory fitted up and passed by the Inspector for Practical Inorganic Chemistry (*see* end of syllabus of Xp., page 65) may be also used for instruction in Practical Organic Chemistry, provided that the appliances commonly employed in organic analysis and investigation are kept for general use in the Laboratory.

SUBJECT XII.—GEOLOGY.

Compulsory Questions may be set at the Examination.

STAGE 1.

The Crust of the Globe. Rocks and their Classification. Crystalline Vitreous and Clastic rocks. Aqueous, Igneous (Volcanic and Plutonic) and Metamorphic rocks.

General characters and composition of the following groups of Minerals: Quartz, Opal, and Chalcedony; Felspars; Micas; Hornblendes and Augites; Calcium and Magnesium Carbonates; Oxides and Sulphides of Iron.

The general characters of the following types of Rocks:—Granite, Diorite, Gabbro; Rhyolite, Andesite, Basalt; Phonolites; Porphyrites; Volcanic glasses, Pumice, Volcanic dust; Conglomerates, Sands and Sandstones; Clays, Shales, and Slates; Limestones and Coals; Rock-salt and Gypsum; Gneisses, Granulites and Schists.

Forms of stratification. Proofs of the original horizontality of strata. False-bedding. Thinning-out and changes in the characters of beds. Ripplemark and other features produced during deposition. Consolidation of strata: Formation of concretions: Jointing: Cleavage: Metamorphism. Elevation: Proofs of slow and violent movements in the Earth's Crust: Bending, Folding, and Inversion of strata. Outcrop: Dip and Strike. Faults of various kinds: Hade and Throw. Denudation—Subaërial and Marine. Escarpments, Outliers and Inliers. Unconformity and Overlap. Drawing simple geological sections.

Fossils: their nature and mode of preservation. Pseudo-fossils. Derived fossils. Use of fossils in distinguishing between marine and fresh-water strata. The meaning of the terms variety, species, genus, family, order. Extinct forms. Faunas and Floras.

Use of fossils in making a chronological classification of stratified rocks. Strata identified by their organic remains. General characteristics of the forms of life in the Cainozoic, Mesozoic, Newer Palæozoic and Older Palæozoic Eras respectively. The order of succession of the great geological systems and the leading characteristics of their British representatives.

Volcanic rocks. Crystalline and glassy lavas. Scoriæ, lapilli, tuffs, &c. Different types of volcanic outbursts. Explosive and effusive action. Volcanic cones and their varieties. Volcanic dykes. Parasitical cones and Composite volcanic mountains. Volcanic craters. Consolidation and alteration of volcanic materials. Volcanic rocks associated with strata of different geological periods.

Plutonic Rocks. Granitic masses and their mode of occurrence: Porphyritic, pegmatitic, and "drusy" varieties. Veins: Dykes: Sheets (sills). Included fragments and segregations. Relations of plutonic masses to the rocks into which they are intruded. Contact metamorphism around plutonic rocks. Evidences of differences of geological age in plutonic rocks.

Metamorphic rocks. Degrees of metamorphic action. Nature of minerals formed by metamorphic action. Distinctive characters of gneisses, granulites, and schists. Foliation. Mineral veins and other ore-deposits. Chief minerals occurring as ores and veinstones. Arrangement of minerals in veins. Relation of mineral veins to rocks which they traverse.

STAGE 2.

Distribution of temperature in the Earth's crust, and the observations by which it is determined. Isogeotherms. Comparison of the density of Earth with that of its Crust. Chemical composition of the Earth's crust and of Meteorites.

The common rock-forming minerals. Their forms of crystallization, physical peculiarities, chemical composition; and the characters by which they can be distinguished in thin sections under the microscope.

The macroscopic and microscopic characters of the common types of rocks. Their chemical composition, mineralogical constitution, and distinctive structures. The changes which rocks undergo as the result of surface and deep-seated action and the secondary minerals formed in them.

Distinction between False-bedding and Unconformity. Conditions of deposition as indicated by characters of strata. Origin of oolitic and other structures in aqueous rocks. Origin of flint and chert. Formations of various nodular structures. Septaria, coal-balls, &c. Varieties of jointing. Origin of joints. Cleavage, its nature and origin. Folds, Faults, Thrusts and their structures. Foliation, slickensides, mylonites, &c. Contact and [illegible]. Nature of Earthquakes and their connection with [illegible]. Calculation of true dip from apparent [illegible] constructing geological sections and maps.

The nature of the processes to which fossils owe their preservation. Fossilization by different mineral substances. Portions of organisms that undergo fossilization. Casts, tracks, burrows, &c. The chief living and extinct groups of the Animal and Vegetable kingdoms. Range in space and time. Persistent types. Synthetic types.

Leading features and characteristic fossils of the series of British formations. Variations in character and thickness of the British formations, and their general correlation with strata in Europe, North America, and other parts of the world.

Volcanic rocks of different composition and structure. Formation of peculiar types of Volcanic products. Banded, spherulitic, perlitic, and pumiceous structures. Volcanic bombs and pseudo-bombs. Pele's Hair. Ejected blocks. Chemical and physical changes which lavas undergo. Comparison of ancient and modern lavas; and explanation of the formation of secondary minerals and structures.

The chief types of Plutonic rocks. Light thrown on their mode of origin by the microscopic study of their structures and of the minerals of which they are composed. Varieties of dykes, sheets, and veins. Distinction between interbedded and intrusive igneous masses. Nature and origin of minerals produced by contact-metamorphism. Tests of age in Plutonic rocks. Veins and included fragments.

Theories of Metamorphism. Thermo-metamorphism and Dynamo-metamorphism. Varieties of foliated structure. The structure of great mountain chains and the succession of operations by which they have been produced. The origin of mineral veins and other ore-deposits. Geological age of different ore-deposits.

In the evening examinations the candidate will be required, in addition to the above subjects, to show some knowledge of the following :—

The chemical composition and economic value of different varieties of coal and other fossil fuels. The nature and origin of natural oils and gas, and of the various bedded deposits which are the sources of useful metals or metallic ores. The chief minerals employed as ores of the heavy metals, and the mode of their occurrence in mineral veins, and similar deposits. The characters of rock-masses which facilitate the quarrying of roofing slates, building stones, and other materials of great economic importance. Marbles and other ornamental stones. Alluvial deposits which yield useful metals. Phosphate, rock-salt, gypsum deposits, &c.

STAGE 3.

The changes of distribution of temperature in the atmosphere and ocean and the nature and causes of the movements that take place in them. Rainfall, springs, rivers and river drainage, glaciers, denudation.

The various deposits formed on land and in the ocean. Deep-sea deposits and the manner in which they are investigated.

Methods of determining positions and heights upon the Earth's surface. The construction of maps and sections. Principles of geological mapping and the drawing of geological sections across maps.

The minor divisions of geological formations, zones, and the methods by which they are distinguished.

A fairly exact knowledge of the microscopical characters of rocks, and of the minerals of which they are made up.

A general knowledge of the characteristic fossils in all the chief British formations, and of the variations in character of these formations when traced over the British Islands and into Europe.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part 1.).

In this examination the student will be expected to have a good general knowledge of Petrology, including the microscopical characters of all but the rarest rocks, and of the minerals composing them.

He will have to show exact knowledge of the method of determining the positions and relations of rock masses, and to be able to draw sections over complicated pieces of country from geological maps.

He must have a fair knowledge of the elements of Palæontology, both of plants and animal forms, especially those which are most characteristic of geological horizons.

He must have a knowledge, not only of the succession of stratified rocks in this country but of their equivalents in Europe and other parts of the world.

Lastly, he must be prepared to give a clear statement of the arguments for and against the most important theories that have been enunciated upon geological problems.

SUBJECT XIII.—MINERALOGY.

Practical Work.

Each candidate for examination in Mineralogy must be provided with a set of the following reagents and apparatus. This set should be of a portable character so as to be available for use in any examination room.

Oil, or Candle Blowpipe Lamp.	Cobalt Glass.
Mouth Blowpipe.	Copper Wire.
Platinum Wire.	Magnesium Ribbon or Wire.
„ Foil.	Borax.
Charcoal.	Sodium Carbonate.
Open and closed Glass Tubes.	Microcosmic Salt.
Silver Foil or Silver Coin.	Cobalt Nitrate Solution.
Magnet.	Hydrochloric Acid.
Knife.	Sulphuric Acid.
Lens.	Litmus Paper, red and blue.
Tinfoil.	Potassium Iodide and Sulphur.

Specimens of minerals will be sent for an examination in which the blowpipe and the above reagents will be used. The specimens sent to be examined will be in the state of coarse powder, and are to be tested as to their physical and chemical properties in accordance with the syllabus so far as the use of the above-mentioned apparatus and reagents will permit.

Two substances will be sent for each candidate to examine. In Stage 1 the candidate will be required to detect the presence of not more than two elements (Hydrogen and Oxygen excepted) in any one specimen. In Stage 2, three or four elements may be present, and should be identified in each specimen, in addition to any Hydrogen and Oxygen that may be present. The comparative fusibility, the effect of heating in closed and open tubes, the colour given to the flame, the encrustation and metallic beads on charcoal, the effects of fusing metallic oxides with borax, and, for Stage 2, with microcosmic salt, should be clearly stated. Candidates in Honours will be required to make a specially full and complete examination of the specimens sent for their use.

Compulsory questions may be set at the examination.

STAGE 1.

Definitions of a mineral and of a crystal. The crystalline and amorphous conditions. Dendritic, concretionary, and other massive forms of minerals.

The elements of Crystallography necessary for the understanding of the laws which govern [illegible] the chief forms which occur in [illegible] Irregularities and [illegible] parallel growths.

The [illegible] mode

AL PROPERTIES.—The cleavage of crystallised substances, and on to crystalline system. Fracture; its varied characters. Com- hardness, and mode of determination. Different qualities of Specific gravity of solids, how determined; the ordinary balance mining specific gravities.

ty of magnetism; what substances are capable of being attracted net, and what is the comparative intensity of the effect. Polarity. l properties of minerals.

arities of smell, taste, and touch which distinguish some

tive Index. Single and double refraction.

nt degrees of lustre and transparency.

s of Minerals; varieties of colour, how far capable of definition.

orescence as produced by different methods and exhibited by inerals.

CAL CHARACTERS.—Simple or elementary substances which occur rals. Chemical combinations; principal groups of these in the mineral kingdom.

phism, trimorphism, etc., of particular substances; accompanied by ce in other physical characters besides form. Isomorphism.

ployment of acids in the discrimination of minerals.

owpipe, its form and uses; the reducing and the oxidizing flames. comparative fusibility, effects of heating in open and closed tubes, lour given to the flame, the encrustation and metallic beads on ; the effects of fusing various metallic oxides with beads of borax ocosmic salt.

ens will be sent for an examination in which the blowpipe and the ple reagents will be required.

OMORPHISM.—The phenomena presented by minerals which have osition of one mineral coupled with the form of another.

ication of minerals. Systems usually adopted.

YSTEMATIC DESCRIPTION OF MINERALS.—This last division should he most important species, as well as the more remarkable varieties common species, and should take especial note of the modes of ce, as well as of the association of particular groups of minerals in eins or formations.

ion should be restricted to the principal species which form the nts of rocks, and to the more common ores from which the etals are obtained.

acquaintance with the nature and composition of the following will be expected in Stage 1:—

nd, graphite, borax, sulphur, calcite, aragonite, dolomite, gypsum, e, apatite, fluorspar, rock-salt, barytes, witherite, celestine, ite, corundum and its varieties, spinel, quartz and its varieties, ny and its varieties, opal and its varieties, the garnet group, leucite, pophyllite, nepheline, tourmaline, beryl and its varieties, the mica me of the most common zeolites, olivine, andalusite, topaz, the group, the amphibole group, talc, chlorite, epidote, the felspar erpentine, kaolin. Pyrolusite, psilomelane, manganite, dialogite, orpiment, realgar, antimonite, bismuth, zinc-blende, smithsonite, , hemimorphite, cassiterite, rutile, galena, anglesite, cerussite, phite, magnetite, chromite, hæmatite, limonite, göthite, pyrite, e, pyrrhotine, mispickel, siderite, (chalybite), and its varieties, , kupfernickel (nickeline), garnierite, native copper, copper-pyrites, lance (chalcosine), bornite, malachite, azurite, chrysocolla, cinnabar, lver, argentite, stephanite, pyrargyrite, proustite, gold, platinum.

STAGE 2.

The relations of the axial system to crystal forms. Symmetry. The methods of indicating the faces, and thence the entire forms of crystals by symbols. Principles of Miller's system of notation. Modification of Miller's system in regard to the hexagonal system. Principles of spherical projection. Employment of the normals to a face.

Examples of twinning in important minerals in the various crystallographic systems. Twin faces and axes. Consideration of interpenetrant and other varieties of twins. Compound twinning.

The prevailing directions of cleavage in the several crystallographic systems; similarity or dissimilarity of different sets of parting planes, according to the system in which a mineral crystallises.

Determination of specific gravity by specific gravity bottle. Contrivances for rapid determination of specific gravity. Use of heavy liquids for the separation of minerals and the determination of specific gravities.

Electricity; by what means this property is exhibited in different minerals. Pyroelectricity. Nature of analogous and antilogous poles. Association of pyroelectricity with hemimorphism.

Propagation of light through crystals; wave-lengths; amplitude of vibration; interference, &c. Reflection of light; total reflection. Refraction of light. Determination of refractive index. Double refraction. Characters of uniaxial and biaxial crystals.

Polarized light, its connection with double refraction. Construction and use of the polariscope. Use of tourmaline plates. Simple reflecting polariscope. Principle of Nicol's prism.

Polarisation with parallel light; directions of extinction. Interference-colours of doubly refracting plates. Circular polarisation. Pleochroism, and the means of determining the existence of this property in a mineral. The Dichroiscope. Face-colours and axis-colours.

Methods of classification as proposed by different mineralogists.

The species of minerals described in ordinary manuals, with a few of their more important varieties. Their occurrence under various circumstances to be particularly studied. The changes in composition wrought by nature (pseudomorphous action), by which one species is converted into another, and the essential points of difference between species much alike in certain characters, will be held of much importance in dealing with the minerals of special value or interest.

In the evening examination the candidates will be required, in addition to the above subjects, to show some knowledge of the following:—

The nature and mode of occurrence of minerals of great economic value, such as asbestus, mica, corundum, apatite, emery, &c., the minerals employed as pigments, abrasives, and gems. Special knowledge must be shown of the minerals employed as ores of the heavy metals, and of those used as sources of aluminium, magnesium, sodium, thorium, &c.

STAGE 3.

Different forms of reflecting goniometers and the method of using them. The fundamental laws of crystallisation. Principles on which the axial ratios are calculated from the measured angles of crystals.

Hardness figures, etched figures, parting planes, and the use of these in determining the symmetry of crystals.

Optical characters of minerals. Use of parallel and convergent polarised light. Interference figures. Stauroscopes and their use. Dispersion. Circular polarisation and the minerals which exhibit this property. Determination of right- and left-handed circular polarisation. Formation of Airy's Spirals.

Isomorphism, Polymorphism, Isodimorphism, Multiple Twinning, Optical anomalies of minerals. Various explanations of these anomalies.

Pseudomorphism. The different varieties of pseudomorphism, and the manner in which they originate.

The chief varieties of all the ordinary species of minerals. Their crystallographic, chemical, and other peculiarities, their mode of occurrence, association, and uses in the arts.

The artificial formation of bodies having the composition and properties of minerals. Minerals from which the rarer elements are obtained.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.).

In this stage a more complete acquaintance will be required with goniometry, the principles of crystal calculation, and the various systems of crystallographic notation.

The thirty-two groups of crystalline forms, with their relations to one another, and the chemical relations of minerals, as illustrated by isomorphism and similar phenomena, must be understood.

A detailed knowledge will be expected of the instruments by means of which the optical characters of minerals are investigated, and of the results obtained by the use of these instruments. The determination of the optical sign, the dispersion and all optical constants, both of uniaxial and biaxial crystals, under various conditions, must have been studied.

An exact knowledge will be required of the characters, association, and distribution of the different mineral species and their varieties. The candidate must also be familiar with the principles on which the natural grouping of species is founded, and with the economic value of certain species and varieties.

SUBJECT XIV.—HUMAN PHYSIOLOGY.

COMPULSORY QUESTIONS MAY BE SET AT THE EXAMINATION.

STAGE 1.

Questions will be confined to the under-mentioned points in the elements of Anatomy and Physiology.

Candidates are expected to have seen the corpuscles of the blood and the fat globules of milk under a microscope magnifying about three or four hundred diameters. Other details of structure needing the use of a microscope will not be asked for.

No candidate will be allowed to pass who in the answers makes gross errors concerning the general build of the body and the relations of its several parts, the structure and working of the heart and the main facts of the circulation, the mechanical and chemical changes of respiration, the chemical nature of food, its changes in the alimentary canal, and its use in the body.

a. THE GENERAL BUILD OF THE BODY.

The form and relative positions of the following parts of the skeleton :—Skull, vertebræ, ribs, sternum; scapula, clavicle, humerus, radius, ulna, carpus, metacarpus, phalanges (of the hand); pelvis, femur, tibia, fibula, tarsus, metatarsus, phalanges (of the foot).

The position in the body, and the general form of the following internal organs :—The brain and spinal cord; the pharynx, gullet, stomach, and intestines; the salivary glands, the liver, and the pancreas; the posterior nares, the larynx, trachea, and lungs; the diaphragm; the kidneys and the great vessels.

OD AND ITS CIRCULATION.

ire of the corpuscles of the blood.
he blood.
esented by blood when it clots.

The general structure of the mammalian heart; the form and arrange[illegible]e ment of its chambers; the nature of its walls; the form and positio[illegible]on of its valves.

The action of the heart in propelling the blood.

The general differences between arteries, capillaries, and veins.

The course of the circulation and the reason why the blood moves i[illegible] in only one direction.

The general character of the blood-flow in arteries, capillaries, and vein[illegible]ins.

The evidence of the circulation obtainable in the living body.

c. Food and its Digestion.

The arrangement of the alimentary canal. The chief food-stuffs and th[illegible] the chemical elements they contain. Examples of the occurrence of protei[illegible]id, gelatine, starch, sugar, and fat in articles of food. The form in whic[illegible]ich nitrogen, hydrogen and carbon enter and leave the body. The organs [illegible] by which substances are excreted from the body.

The changes produced in food by mastication and by the action [illegible] of saliva. The chief changes produced in food by digestion in the stomac[illegible]h and in the small intestine. The action of the pancreatic secretion. Th[illegible]e purpose of the digestive changes.

d. The Absorption and Distribution of the Digested Products.[illegible].

The general form and function of villi. The chief differences betwee[illegible]en lymph and blood. The nature of chyle. The discrimination between th[illegible]h substances absorbed by the intestinal lymphatics and those absorbed int[illegible]t the intestinal blood. The character and use of the portal circulation. Th[illegible]h position, general structure and blood supply of the liver.

The more obvious characters and properties of bile.

e. Respiration.

The structures composing the framework of the thorax. The manne[illegible]r in which the walls and floor of the chest change their position during th[illegible]h respiratory movements, and the muscles which alter the size of the thorax.[illegible]x

Why air enters and leaves the chest during inspiration and expiratio[illegible]o respectively.

In what respects the air which leaves the lungs differs from that whic[illegible]ch enters them. The necessity for oxygen being inspired and carbonic aci[illegible]id being expired.

The obvious differences between venous and arterial blood. Where an[illegible]nd how venous blood is converted into arterial, and arterial into venous bloo[illegible]od in the body. How venous blood can be converted into arterial blood out [illegible] of the body.

f. The Muscular System, Animal Mechanics and Animal Hea[illegible].

The structural differences between muscle and tendon, and the functio[illegible]ns of these two forms of tissue. The movements of a limb as examples [illegible] of the results produced by muscular action. The meaning of the te[illegible]ms "origin" and "insertion" as applied to a muscle. The meaning of [illegible]he terms extensors, flexors, abductors, and adductors as applied to [illegible]he groups of muscles moving a limb.

The nature of joints, with examples of ball-and-socket, saddle, hinge, [illegible]and pivot joints. The di[illegible]es, with examples of them in the body.

g. The Senses.

The different kinds of sensations.
The general structural arrangements of the eye-ball. Such characters of e cornea, sclerotic, choroid, iris, aqueous and vitreous humours, crystalline ıs and retina, as can be observed by ordinary dissection.
The parts of the eye-ball traversed by rays of light, and the alteration us produced in the direction of the rays.
The blind spot, and what it teaches.
The essential facts as to the structural arrangements of the ear so far as ey are required to explain how sound-waves are conveyed to the nerves of aring.

h. The Nervous System.

The distinction between motor and sensory nerves as regards the parts ıy go to, and the results produced by nervous impulses passing along ım.
The structure of the spinal cord so far as it is visible to the naked eye.
The structures concerned in simple reflex movements of a limb.
The evidence that the spinal cord is capable of effecting reflex action.
The general phenomena presented by the brainless frog. The effect upon mammal of destroying the medulla oblongata. The distinction between ıeral and local death.

PRACTICAL DEMONSTRATIONS.

Candidates are expected to be able to describe in the written examination ı chief facts brought out by the following experiments or observations. e experiment should be either demonstrated by the teacher or carried t by the pupil in connexion with those lectures which deal with the anches of the subject mentioned below.

(1) Blood and the Circulation.

The microscopic appearance of human blood.
The appearance of defibrinated (whipped) blood and of the fibrin which ı been got from the blood by stirring.
The characters observed when blood has clotted and when having been ɔt the clot has shrunk.
The colour of fresh blood or a recent blood clot and that of blood when ıas been kept.
The difference in colour between the surface and the interior of a blood t.
The place where the radial pulse is felt; the number of pulsations per nute of the radial pulse and the effect upon this number of muscular ırtion.

(2) Food and its Digestion.

The microscopic appearance of a drop of dilute milk. The appearance l smell of a proteid, a sugar and a little fat when heated to dryness so as burn. The changes produced by similarly heating milk. The action of ine on starch, on flour, and on a slice of bread.
The action of saliva in altering a weak solution of starch, the alteration ing disclosed by the iodine test; the favourable influence of warmth, :h as that of the body, in promoting this alteration; the impossibility producing the alteration when the saliva has been previously boiled.
The appearance presented when a solution of white of egg is boiled. e effect of treating coagulated white of egg with 0·3 per cent. hydro- oric acid and Benger's liquor pepticus (artificial gastric juice). The ɔct of boiling the liquor pepticus before use.

(3) Respiration.

The number of respirations per minute when the body is tranquil and en there has been muscular exertion. The result of breathing into lime ter.

The structure of the liver, and the course of the blood through it. The arrangements of the ducts of the liver. The composition and functions of the bile.

d. RESPIRATION.

The structure of the thorax. The pleuræ. The structure of the respiratory organs, and the distribution of the blood through them. The analysis of the respiratory movements in detail. The causation of the diminished intra-thoracic pressure, and the effect on this of inspiration. The mechanism by which coughing, sneezing, sighing, and hiccoughing are effected. The gases of venous and arterial blood. The physical and chemical processes involved in the conversion of inspired into expired air, and of venous into arterial blood. The respiratory activity of the tissues and the conversion of arterial into venous blood.

The manner in which the nervous system regulates the respiratory movements; the respiratory centre. How the nervous mechanism of respiration is affected: (1) by nervous influence, (2) by chemical changes in the blood. The phenomena of dyspnœa, apnœa, and asphyxia.

The influence of the respiratory movements on the circulation.

e. EXCRETION.

(1) The minute structure of the kidney, ureter, and bladder.

The circulation in the kidney, and the changes which the blood undergoes in passing through it.

The nature of the secretory activity of the kidneys, of its relationship to the glomeruli and tubules, and the circumstances which affect it.

The quantity and nature of the waste products of all kinds excreted by the kidneys in 24 hours. The distinctive chemical characters of urea. The physiological significance of the nitrogenous compounds in urine.

(2) The minute structure of the skin; the functions of the skin and its contained structures; the blood capillaries of the dermis and the conditions which alter their blood capacity.

f. NUTRITION; METABOLISM; ANIMAL HEAT.

The statistics of nutrition; the income and output of the body, how they balance.

The uses of proteid, gelatinous, fatty, and carbohydrate food stuffs. The effect on metabolism of the following conditions: (1) excess or deficiency of nitrogenous and non-nitrogenous food, (2) muscular exercise.

The energy of the body, its source and expenditure; the amount and character of the daily expenditure.

The sources of the production and the loss of animal heat; their balance during health; how maintained and regulated by changes: (1) in the amount of loss, (2) in the amount of production.

g. THE MUSCULAR SYSTEM AND ANIMAL MECHANICS.

The minute structure of cartilage, bone, connective tissue, and muscle. Cilia and ciliary action.

The mechanical changes which take place in a muscle during contraction. The characters of a simple and of a tetanic contraction. Rigor mortis.

The mechanism of standing and walking.

[illegible] the larynx; the movements of the glottis.

h. THE SENSES.

[illegible] papillæ and nerve endings in the skin. The sensation.

[illegible] of the tongue and of taste bulbs.

The structure of the olfactory organ. The nature and extent of the air-chambers connected with it.

The minute structure of the various parts of the eye-ball.

The formation of the image on the retina.

The conditions of distinct vision. Accommodation; its mechanism, limits and defects.

Movements of the pupil.

The ophthalmoscope; the retinal blood vessels. Evidence that visual impressions begin in the rods and cones. The peculiar characters of visual sensations, their duration, the influence of fatigue, the fusion of successive sensations, the production of colour perception.

Movements of the eye-ball. Binocular vision. Judgments of distance, form, and solidity.

The structural arrangements of the organ of hearing. The outer-ear. The structure and functions of the middle-ear. The position, structure, and function of the Eustachian tube. The minute structure of the inner-ear. The parts forming the bony and membranous labyrinth.

Auditory sensations. Use of two ears.

i. The Nervous System.

The minute structure of nerves; medullated and non-medullated nerve fibres. The forms of nerve cells in the spinal cord, posterior root and sympathetic ganglia.

The sympathetic system, its general structure and its anatomical and physiological relations to the cerebro-spinal system.

The minute structure of the spinal cord; the more important structural differences observable in different parts of the spinal cord.

The chief characters of reflex actions. The connexions of the posterior and the anterior roots, and the function of the nerve fibres they contain.

The relative positions of the following parts: Medulla oblongata, cerebellum, pons, crura cerebri, corpora quadragemina, cerebral hemispheres, corpus callosum, olfactory bulbs, and optic tracts.

The peripheral distribution, course, and general functions of the twelve pairs of cranial nerves.

STAGE 3. (Theory).

Candidates will be required to show knowledge of the subjects set forth in the syllabus for Stages 1 and 2 with the additional matter indicated in the subjoined syllabus. They will be expected to be familiar with the minute structure of the tissues and organs, and with histological work.

a. Physiological Chemistry.

The constitution, properties, and distinguishing characters of the substances in the animal tissues, secretions, and excretions. The nature and action of enzymes; the chemical processes associated with digestion, absorption, respiration, excretion; general metabolism; the special metabolism of muscles, glands, and other organs. The influence of metabolism of different bodily conditions. The internal secretions of various organs, and their influence upon metabolism.

b. General Physiology of the Excitable Tis-

c. The Physiology of the Central Nervous System.

The anatomical relations, minute structure, cellular connexions and distribution of the various spinal, cranial and sympathetic nerves. The minute structure of the different parts of the central nervous system in a typical mammal. The reflex functions of the nervous system; reflex tone; special reflexes; the paths involved in the conduction of afferent and efferent nervous impulses. The excitability of the central nervous system and the conditions which modify it. The configuration of the cerebral cortex in the dog, monkeys and man; the localisation of function in the cerebral cortex; the changes produced by ablation of portions of the nervous system in different animals. The anatomical connexions and the functions of the cerebellum, the optic lobes, the basal ganglia and the internal capsule.

d. The Physiology of the Special Senses.

The Structure of the Sense Organs.—The characteristic features of the different sensations, their physiological basis, their time relations, their relationship to the stimuli which evoke them, and their localisation in reference to the different sense organs. The dioptrics of the eye, the function of the neuro-muscular structures of the eye, intrinsic and extrinsic; the changes produced in the eye by the action of light. Theories of colour perception. Binocular vision. The visual perception of distance. The limits of hearing; the analysis of tones; theories of hearing. The function of the semi-circular canals. The Muscular Sense.

STAGE 3. (Practical).

Candidates will be required to show their practical knowledge of histological work and of physiological chemistry by reporting upon microscopic specimens and upon samples containing the commoner substances of physiological importance.

No candidate will be credited with a first class in Stage 3 who does not pass in both the Theoretical and Practical parts of the examination.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.). Questions will be set at the discretion of the examiners, who will have regard to the state of teaching of Physiology in the country, and the means of acquiring information. Candidates will be expected to show a critical appreciation of the evidence on which physiological statements are based.

Those candidates who answer the questions in the written paper in a sufficiently satisfactory way will be required to undergo a practical examination at a subsequent date. No candidate can be classed in Honours who is not successful in the practical examination.

It is to be clearly understood that the standard of the final examination for Honours is a high one. A class in Honours will not be awarded unless a candidate shows that he has made Physiology the subject of prolonged and careful study, and for this purpose has worked in some efficient Physiological Laboratory during a portion of his period of study.

SUBJECT XV.—GENERAL BIOLOGY.

Compulsory questions may be set at the examination.

The syllabus of General Biology, Stage 1, is divided into two sections, Section I. being an introduction to the knowledge required for all Biological subjects. A paper will be set in Section I. at the same time that the paper in Section II. is taken. The paper in Section II. will contain questions from Section I., of which a certain number must be answered in order to obtain a pass in that Section.

STAGE I.

Section I.

General Instructions.

The observations and experiments here specified should not be described to the class, but demonstrated, and whenever possible, demonstrated by the class to the teacher, rather than by the teacher to the class. Only so much explanation should be given as is necessary to bring out the meaning of what has been seen and done. It is enough that the facts should be carefully studied, and plain inferences drawn; theories are unsuited to young persons who are acquainted with few concrete facts. Technical terms should be avoided as much as possible; with a little thought plain English can generally be made to do. Drawing direct from the object is an excellent way of recording information, and a great help to the work of succeeding stages; the drawings should be made to scale, and in as workmanlike fashion as possible. The chief function of the teacher is not to give information, but to help the class to discover for themselves.

*** The tests will include the description, drawing and interpretation of simple natural objects not named in the syllabus.

The Growth of a Plant.

1. Seedlings of Bean should be raised in flower-pots. Show the contrast between seedlings grown in full light, and seedlings which have been partly or completely shaded. Continue the observations for some weeks, and take weekly measurements of the height and weight of fairly selected seedlings. (The plant should be thoroughly dried in a water-oven before weighing.) Plot the results in curves.

2. Demonstrate the formation of starch in green leaves in the presence of sunlight, and its disappearance in the dark, by Sachs' iodine test. A quite elementary account of starch and iodine (sources, uses, characteristic peculiarities, &c.) should be given and practically illustrated. All leaves are not equally suitable, but primrose, tropæolum, cabbage, and marigold answer well. Try at least one new leaf every year, and note those which do or do not answer well. A variety of simple ways can be found of excluding light from parts of leaves which are still attached to the plant. For example, a card with the letter S cut out of it may be fixed to a leaf which has been kept in the dark for twenty-four hours. The leaf is then to be exposed to full sunlight through the day, killed by boiling water, and decolorized by alcohol. On placing the leaf in iodine solution diluted to the colour of sherry, the letter will appear. On replacing the leaf in alcohol it will fade. The same leaf can be used any number of times. Every detail of the experiment should be shown to the class, if possible. It is well not to anticipate future experiments by mere explanations.

3. The absorption of nutritive substances by roots. One or two very simple water cultures will show that plants can be nourished by dissolved salts taken up by the roots. Show that seeds supplied with a suitable nutritive solution* grow faster and stronger than similar seedlings supplied only with plain water.

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* For example—

Potassium nitrate	1	gramme.
Sodium chloride	¼	"
Calcium sulphate	¼	"
Magnesium sulphate	¼	"
Calcium phosphate	¼	"
Water	1	litre.

A few drops of dilute solution of iron chloride should be added.

Flowers, Fruit and Seeds.

4. The parts of a flower and their uses. Description of two or three common flowers (at the choice of the teacher) in the least technical language that can be found. The plan of construction of each flower is the chief thing to attend to; drawings and models made by the class will give excellent practice.

5. Pollination and fertilisation. Pollen and pollen-tubes may be shown by the microscope, and simple explanations given. Dig up in early summer several plants of red clover, and place them in large flower-pots. Screen half of them from the visits of insects by fine gauze spread over the plants, and supported by wires. Place all the pots together in a sunny place, water as required, and note which ripen seed. Try also a second plant of another species taken at hazard, a different plant each year, and note the results. If clover in flower cannot be procured owing to the time of the year, the experiment may be made with primroses.

6. Examine the structure of some common fruits (apple or pear, cherry or plum, orange, dandelion, sycamore, pine or birch, field geranium, pansy, herb bennet). The technical information given in botanical text-books is not required. Observations should be made on the mode of dispersion of these and other common fruits, occasionally at least out of doors.

7. The germination of seeds. Spring and summer are the most convenient seasons. Maize, sycamore, lupine, and vegetable marrow seeds should be grown in wet sawdust, and examined frequently. Careful drawings should be made. The roots and root-hairs require particular notice.

8. Buds of sycamore and horse-chestnut should be studied in winter, and also during the expansion of the buds. The time and place of formation of new buds should be noted. Paper models of the buds will illustrate the folding of the leaves, &c.

Life Histories of some Common Insects.

9. The Cabbage White Butterfly, the Tiger Moth, the Vapourer Moth, and Chironomus should be reared. Boxes (say 18 in. × 8 in. × 6 in.) without bottom are suitable for caterpillars; one of the larger upright sides should be of perforated zinc, and the other of glass. The food plants may be stuck in a bottle of wet sand inside the case. Chironomus larvæ (blood worms) are very common during the warmer half of the year in slow streams; they feed on decaying vegetation. The eggs are laid many together in transparent ropes, nearly an inch long, which are easily found in horse-troughs, stone-fountains, &c., during the summer months; they are moored to the side at the top of the water. All the stages of this insect except the winged fly may be kept in a shallow dish. Drawings and notes should be made of the transformations.

Tadpoles and Frogs.

10. All the stages should be studied as thoroughly as can be done without the use of the microscope or dissecting instruments. Drawings should be made. A simple lens will often be of use for Sections 9 and 10.

The General Structure of a Bird.

11. The feathers, wing, beak and other external features should be carefully examined. The skeleton should be studied, especially in relation to support and locomotion. Very few technical terms are required; the chief thing is to form a clear mental picture of the structures and of their special adaptations.

Some Common Quadrupeds.

12. The external features and mode of life of the cat, dog, rabbit, sheep and bat should be observed, *e.g.*, hair or fur, eyes, teeth, hoofs or claws, food, modes of locomotion, likes and dislikes, habitations, &c. A skeleton of one of these animals should be accessible, and a few of its peculiarities should be pointed out.

Elementary Physiology.

13. Very elementary lessons should be given on digestion, circulation, and respiration. A sheep's heart should be dissected. Simple experiments should be made on the changes which air undergoes in the human lung.

STAGE 2.

Section II.

For Section II. of Stage 1 candidates will be expected to show a practical acquaintance with the following subjects.

1. The general anatomy of a Frog, as an example of a Vertebrate animal. The skeleton of the frog; its component parts, and their uses and relations to other organs. The structure and arrangement of the digestive, circulatory, respiratory, excretory, and nervous systems of the frog, and the uses and modes of action of their several parts. The peculiarities of structure which enable the frog to endure long immersion in water; its mode of self-protection.

The life-history of the Frog. The eggs and their mode of deposition; the early stages of segmentation, as observed by a simple lens: the nutrition and mode of life of the Tadpole; the changes which convert it into a Frog.

2. The microscopical characters of the tissues specified below, and the ultimate formation of all parts of the body from nucleated cells. The various kinds of epithelial cells; their distribution and uses. Connective tissue; cartilage; bone; nerve cells, and nerve fibres.

3. The characters of the blood-circulation as seen in the web of a frog's foot. Arteries, veins, capillaries. The blood corpuscles, red and white. The uses of the blood, and the modes and places in which these are effected.

4. Unicellular organisms. The form, size, and structure; the modes of growth and multiplication; and the conditions and results of the living activity of Saccharomyces, Protococcus, and Amœba.

5. The structure and mode of life of a common Mould (Penicillium). Its vegetative reproduction and dispersal.

6. The structure and life-history of a Fern (Pteris). The general structure of the sporophyte in connexion with its mode of life. Sporangia and spores. The structure and development of the prothallium. The sexual reproductive organs and the early stages of development of the sporophyte.

7. The structure and life-history of a Bean or other Flowering Plant. The structure of the stem, the root, and the foliage leaf in connexion with their functions. The structure of the flower; the calyx, the corolla, the androecium, the gynœcium; the floral leaves, sepals, petals, stamens and carpels. The structure of the anther; the pollen sacs and the pollen grains. The structure of the ovary; the ovule, and the embryo-sac with its contents. The processes of pollination and fertilisation; the products of fertilisation; the fruit; the seed.

The physiology of the flowering plant. The physiology of nutrition in connexion with the presence of chlorophyll: the absorptive, assimilative, and transpiratory organs; conduction of liquid from the roots to the leaves; transpiration; the distribution of the organic substances formed in the leaves.

Experimental proof of the following:—

(*a.*) Starch-formation in green plants supplied with carbon dioxide and sunlight. (Sachs' iodine method. Moll's experiment.)

(*b.*) The uses of dissolved salts in the nutrition of green plants. (Water cultures.)

(*c.*) The path by which water ascends to the leaves (removal or obstruction of systems of tissue in a living woody stem).

(*d.*) The path by which nutritive organic substance passes from the leaves to other parts of the plant (ringing and ligature of living woody stem).

*** It is expected that all the above experiments will be demonstrated to the class. Sunlight at the time of demonstration is not indispensable.

9. The fundamental facts respecting the nutrition of animals. Digestion by single cells. Digestive glands and their secretion. Digestion and absorption as they occur in Vertebrate animals. Demonstration of the action of human saliva upon starch. Proof that the warmth of the body is necessary, and that the activity of the saliva is destroyed by boiling.

Comparison of the nutritive processes of green plants, moulds, and animals. The way in which plants aid the nutrition of animals, and animals the nutrition of plants.

10. The chief distinctive characters of plants and animals

STAGE 3.

For Stage 3 a knowledge of the following subjects will be required in addition to those included in the syllabus for Stage 2. Candidates will be expected to show a practical acquaintance with the types mentioned.

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1. The structure, mode of life and reproduction of Amœba.

2. The Earthworm (Lumbricus). The general structure of the earthworm; the division of the body into segments or somites. The mode of life of the earth worm; the action of earthworms in the formation of vegetable mould.

3. The Crayfish (Astacus). The general structure of the crayfish, and its mode of life. The exoskeleton and its several parts; the mode of growth; the appendages; their common plan, and their adaptations to special purposes. (Any intelligible method of denoting the appendages and their parts will be accepted.) The structure, arrangement, and mode of action of the several organs; and especially the digestive, circulatory, respiratory, and nervous systems.

4. The Dogfish (Scyllium). The general structure and mode of life of a dog-fish. The external characters; the scales and teeth; the fins. The chief features, but not the details, of the skeleton of the dog-fish. The structure, arrangement, and mode of action of the several organs; and especially the digestive, circulatory, respiratory, and nervous systems. The main points of resemblance and of difference between a dog-fish and a frog.

5. The eye of the sheep. Such knowledge is expected as would be acquired by ordinary dissection.

6. The outlines of the development of the Frog. The formation of the eggs. Fertilisation and segmentation of the eggs. The development of the tadpole, and especially of its nervous system and alimentary canal. The changes that occur during the metamorphosis of the tadpole into the frog.

7. The structure, including the minute structure, and the functions of a green leaf.

8. The pollination and fertilisation of flowering plants. The formation of the fruit and seed.

9. The germination of seeds, including the conditions necessary to germination, and the chemical changes involved. The food-reserves of seeds and the changes which they undergo during germination.

Practical experimental knowledge of the subjects included in Sections 7, 8 and 9 is expected.

m; the general structure, and particularly
roductive organs. Comparison of these
an Angiospermous Flowering Plant.
t XVI. or Subject XVII. or both should

Suggested Laboratory Arrangements for Practical Work in Biology and Physiology.

A moderately well-equipped Laboratory should be provided with fittings as follows :—

The Laboratory should be a well-lighted room and should if possible be capable of being darkened, by means of dark blinds, for simple experiments on light and vision.

Strongly made tables with tops of well-seasoned wood, unpolished. They may be made so as to allow of a space of at least 4 ft. × 2 ft. for each working place.

Gas or electric light should be laid on to each bench, and it should be so arranged that a stand lamp for each working place can be attached, for work at night or on dark days.

Sinks with water supply and waste should be placed in convenient positions. At least two should be supplied in a Laboratory for 24 or 25 students ; one of them being a large one for washing up purposes, &c. Instead, however, of one small sink in addition to the large one, it will be found preferable to have a number of small sinks fitted into the working benches as in a Chemical Laboratory, one for each two working places.

Adequate cupboard space should be provided for storing apparatus, and a large lead-lined box in which to keep dissected specimens will be useful.

The following apparatus should also be provided, in addition to that required for the theoretical instruction :—

Dissecting instruments and trays, one set for each student.

Microscopes (compound) one for each working place.

A sufficient stock of chemical apparatus for all the students to work at experiments in respiration, digestion, circulation of blood, &c.

Some simple form of microtome.

Under special circumstances some of these requirements may be relaxed.

SUBJECT XVI.—ZOOLOGY.

Compulsory Questions may be set at the Examination.

STAGE 1.

Questions will be confined to the following subjects, with which the candidate will be expected to show a practical acquaintance.

1. The external features, general anatomical structure, mode of life (feeding, locomotion, self-protection), and life-history of the following animals :—Frog, Crayfish, Cockroach, Earthworm, Pond-mussel, Hydra, Vorticella, Amœba. Practical, but not detailed, knowledge of each animal is expected. Technical names for the organs and parts are not insisted on.

2. The skeletons of a frog, a bird, and a mammal. (The adaptations of the skeleton to support, locomotion, and prehension of food should receive particular attention.)

3. The structure of feathers, hairs, and scales (of Fishes). (An elementary knowledge only is expected.)

4. The Fowl's egg and the history of the development of the chick up to the fourth day of incubation. (Practical acquaintance with the incubated egg is expected, but it is not supposed that sections will be examined or described.*)

* If a sitting hen cannot be had, a simple kind of incubator can easily be fitted up. A chemical water oven, heated by a self-regulating gas jet, can be made to do very well for the early stages of hatching.

The characters of the classes of Vertebrates. Reference of common ıbrates to their classes.

The characters of Arthropods and Mollusks and of their chief classes. ence of common Arthropods and Mollusks to their classes.

STAGE 2.

estions may be set on the following subjects, in addition to those led in the syllabus for Stage 1. Candidates are expected to an adequate practical knowledge of the anatomical structure, ıal characters, mode of life, and life-history (subsequent to hatching) e animals named, except where particular parts only are expressly ıted. Dissection and drawing should be freely practised.

Mammalia. The skeleton of the Rabbit in detail. The distinctive res (visible without dissection, but including those drawn from the on and teeth) of the indigenous orders.

Aves. The Pigeon, including the skeleton. The development of the : as studied by fresh and permanent preparations of entire embryos.

Fishes. The Cod or Haddock, including the skeleton.

Insects. The Honey-bee and Harlequin-fly (Chironomus) in all their s (external structure only). The adaptation of these insects to their undings, and the adaptation of the Honey-bee to the social state.

The characters of the following divisions of the animal kingdom :— zoa, Porifera, Cœlentera, Annelida (Chætopoda included), Arthropoda, usca, Chordata.

The characteristic features of the marine, fluviatile and terrestrial s. The main facts relating to the geographical distribution of malia. Outlines of the geological history of Mammalia.

Either A. or B.

A. Marine.

e structure and life-history of the Cuttlefish (Sepia or Loligo), Whelk, ; Crab, Stalked Barnacle, Starfish, Compound Hydroid (Obelia). The ations of these animals to their mode of life.

B. Fluviatile.

e structure and life-history of Paludina, Anodon, Daphnia, Leech, Hydra, Paramecium. Anodon and Hydra are to be studied in more than was possible in Stage 1. The adaptations of these animals to mode of life.

STAGE 3. (Theory).

e examination will include questions, and the candidate must be red to undertake practical work, on—

The structure and life-history of the following animals :—The common water Protozoa, Spongilla, Cordylophora, Aurelia, Nereis, Bugula, nia, Lepas, Cancer, Gammarus, Scolopendra, Periplaneta, Dytiscus, Pieris, Chironomus, Mya, Chiton, Helix, Buccinum, Sepia, Uraster ia, Amphioxus, Perca, Raia, Columba, Lepus.

The elements of Comparative Osteology.

STAGE 3. (Practical Examinations).

ndidates will be required to show their practical knowledge of ogy by examining and reporting upon specimens, microscopic or other- sent for that purpose, or by carrying out simple Zoological dissections.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours Part I.).

Those candidates who answer the questions in the written paper in a sufficiently satisfactory way will be required to undergo a practical examination at South Kensington at a subsequent date. No candidate can be classed in Honours who is not successful in the practical examination.

The examination will be partly written and partly practical. The written paper will include questions on the following subjects :—

(1.) Animal Histology. Candidates must be prepared to mount, identify and describe the tissues.

(2.) The development of the Tadpole, Chick, Chironomus, and Limnæa. A practical and detailed knowledge of these is expected, together with a more general knowledge of the development of Amphioxus, Scyllium, and Lepus.

(3.) The classes and orders of the Animal kingdom. A knowledge of the more important typical or aberrant genera is expected.

(4.) Modes of reproduction of animals. Transformations.

(5.) The distribution of Vertebrata. The characters and sub-divisions of the zoological regions. The interpretation of the facts of distribution.

(6.) The elements of Palæontology. (An acquaintance with the problems rather than with the special facts of Palæontology is expected.) The structure of the following animals and their relations to recent forms :—The extinct Proboscidea and Edentata, Archæopteryx, Pterosauria, Iguanodon, Ichthyosauria, Plesiosauria, Labyrinthodonta, the extinct Cephalopoda.

For suggested Laboratory arrangements for practical work in Biological subjects, see page 86.

SUBJECT XVII.—BOTANY.

General Syllabus.

The enumeration of subjects is not intended to do more than guide the teacher. The examination will be especially directed towards ascertaining the amount of knowledge which has been practically acquired by the students. Hence the teaching should always be conducted, wherever possible, with reference to actual specimens which can be handled and examined by each individual in a class. It is especially important that the part dealing with Vegetable Physiology (see III. below) should be taught experimentally, and that the students should perform the experiments themselves. Many of the more fundamental experiments can easily be arranged with home-made apparatus and at a very trifling cost.

Compulsory questions may be set at the examination.

STAGE 1.

General Morphology, Histology, and Physiology.

I. The differentiation of the plant-body into root, stem, and leaf.

i. The morphology of the root and its modifications; the branching of the root.

ii. The morphology of the stem and its modifications; the modes of branching of the stem; the structure and position of buds; vernation.

iii. The morphology of the leaf; the different kinds of leaves; the branching of the leaf; the different parts of the leaf; leaf-base, stipules, petiole, blade; their special modifications; the arrangement of leaves on the stem.

II. The structure of the organs and members, including—

i. The chief characters of the vegetable cell, including an *elementary* knowledge of its chief constituents and contents.
The protoplasm, nucleus, plastids.
The cell-wall, starch-grains.

ii. The structural characters and distribution of the tissues, in so far as they can be made out with the help of a good lens.
The tegumentary tissues, stomata, lenticels.
The cortical and medullary tissues, medullary rays.
The vascular tissues, distinctions between wood and bast.

III. The functions of the various organs; the relation of their structure to their functions.

i. The chemical nature of the food-elements of plants. Their sources, and the modes in which they are respectively absorbed by the organism.

ii. The absorption of water. Turgescence. Movement of water in the plant. Transpiration, its significance. Methods of demonstrating and of measuring its rate.

iii. Photosynthesis (carbon-assimilation) in green plants. The chemical nature of the chief organic substances formed within the plant, starch, cellulose, sugars, fats, albuminoids.

iv. Aeration of the tissues by means of intercellular spaces.

v. Respiration. Its significance. Methods of demonstrating its occurrence.

vi. Growth. Determination of the rate of growth in stems and roots. Conditions which affect growth.

vii. Irritability as manifested by growing and motile organs. Geotropism, heliotropism, movements due to mechanical or chemical stimuli, *e.g.*, the stamens of Barberry, the tentacles on the leaf of Sundew.

Special Morphology and Physiology of the Angiospermous Flowering Plant.

The inflorescence and its modes of branching; bracts: the difference between definite and indefinite inflorescences: the distinctive characters of the following kinds; raceme, spike, spadix, corymb, panicle, umbel, head, cyme, glomerule.

The morphology of the flower and its organs; torus (or receptacle), perianth, androecium, gynoecium: æstivation: the symmetry of the flower: the modifications of the flower due to cohesion, adhesion, suppression, and multiplication of the various parts.

The calyx: the sepals; their form, arrangement, and function.

The corolla: the petals; their form, arrangement, and function.

The androecium; the structure and use of the stamen; the filament, anther, pollen-sacs, pollen.

The gynæcium; the structure of the carpel; the stigma, style, ovary, placenta.

The structure and form of the ovule; the embryo-sac and its contents.

The processes of pollination and fertilisation.

The morphology of the fruit the distinctive characters of the different

nce or absence of albumen (endosperm, n of the embryo, nature of the aril. ds. The various modes of germination.

persistence of the individual plants:

The concise description of fresh plants, taking the organs in t following order :—

Root.	Corolla.
Stem.	Androecium (Stamens).
Leaves.	Gynæcium (Pistil).
Inflorescence.	Ovule.
Bracts.	Fruit.
Flower.	Seed.
Clayx.	Embryo.

The distinctive characters of the classes Dicotyledons and Monocotyledo and of their principal divisions.

In this stage strictly elementary questions only will be set on the subje enumerated above. A knowledge will be required of the characters (cluding general properties) of the following natural orders, to be recogni upon fresh specimens :—

Ranunculaceæ.	Scrophulariaceæ.
Cruciferæ.	Boraginaceæ.
Caryophyllaceæ.	Labiatæ.
Leguminosæ.	Salicineæ.
Rosaceæ.	—
Umbelliferæ.	Liliaceæ.
Compositæ.	Amaryllidaceæ.
Solanaceæ.	

STAGE 2.

Candidates will be expected to possess a fuller knowledge of the subje cts included in the syllabus of Stage 1, and also to shew an acquaintance w ith the microscopic structure of the organs, tissues, cells, and cell contents.

They will also be expected to exhibit a practical acquaintance with the following additional natural orders : Violaceæ, Malvaceæ (including *Til ia*), Geraniaceæ, Onagraceæ, Crassulaceæ, Saxifragaceæ (including *Ribes*), Ca pri-foliaceæ, Campanulaceæ, Ericaceæ, Oleaceæ, Primulaceæ, Plantagi eæ, Chenopodiaceæ, Polygonaceæ, Euphorbiaceæ, Urticaceæ, Amentif eæ, Orchidaceæ, Iridaceæ, Gramineæ.

They will also be expected to exhibit a practical acquaintance with :—

I. The morphology of GYMNOSPERMS, as exemplified by Pinus or P icea.

II. The morphology of the VASCULAR CRYPTOGAMS, as exemplifie d by Selaginella and Aspidium.

III. The morphology of the MUSCINEÆ, as exemplified by Funari a and Pellia.

IV. The morphologyof the ALGÆ, as exemplified by Fucus, Spi rogyra, Hæmatococcus (Sphærella).

V. The morphology and physiology of the FUNGI (including Lic hens) as exemplified by :—

Agaricus.	Pythium.
Eurotium.	Mucor.
Parmelia (Physcia) or Collema.	Saccharomyces.

Note.—Where alternative types are prescribed it is not contemplated that either of them should be entirely neglected. One of the two type should be selected for detailed study ut the principal general characters of the other should also be poi by the teacher.

In addition to a highe in the foregoing syllab to show a general kn

(1) the British a Palmæ, Sc

(2) the principal forms of the Gymnosperms, Vascular Cryptogams, Muscineæ, Algæ, and Fungi, with the following fossil types (together with their fructifications). *Lepidodendron*, *Lyginodendron*, *Sphenophyllum*, *Cheirostrobus*, *Calamites*.

(3) the characteristics and affinities of the great groups of plants.

(4) the general Biology (Bionomics) of plants, including adaptation to environment, origin of species, natural selection: the characteristic features of the various plant-societies (Ecology):

(5) Vegetable Physiology of a more advanced character than in Stages 1 and 2.

HONOURS.

No Candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours Part I.).

In Honours, questions will be set at the discretion of the examiners, who will have regard to the state of teaching of Botany in the country, and the means of acquiring information. Candidates will be expected to show a critical appreciation of the evidence on which our present knowledge and theories are based.

Those candidates who answer the questions in the written paper in a sufficiently satisfactory way will be required to undergo a practical examination at a subsequent date. No candidate can be classed in Honours who is not successful in the practical examination.

It is to be clearly understood that the standard of the final examination for Honours is very high. A class in Honours will not be awarded unless a candidate shows that he has made Botany the subject of prolonged and careful study, and for this purpose has worked in some efficient Botanical Laboratory during a portion of his period of study.

For suggested Laboratory arrangements for Practical Work in Biological subjects see page 86.

SUBJECT XVIII.—PRINCIPLES OF MINING.

The subject is divided into two branches:—

(A.) Mining under the Coal Mines Regulation Act, 1887, which applies to mines worked for coal, stratified ironstone, shale, and fireclay.

(B.) The extraction of minerals from the crust of the earth by workings not comprised under the Coal Mines Regulation Act.

Papers are set for three Stages and for Honours.

Candidates for examination in Stages 1, 2 or 3 must confine themselves either to the questions in Branch A or to those in Branch B.

The questions for Honours will be taken both from Branch A and from Branch B.

Compulsory questions may be set at the examinations.

STAGE 1.

MINING.—BRANCH A.

(Coal, stratified ironstone, fireclay, and shale.)

I. Occurrence.

d and unstratified rocks. Lamination or
l varieties of stratified rocks. Dip and
s. Jointing. Cleat. Unconformability.
nds. Measurement of their throw.
fault or dislocation.

Minerals worked under the Coal Mines Regulation Act, viz., coal, stratified ironstone, shale, and fireclay. Various kinds of coal; geological formations in which workable seams of coal occur. Rocks forming the roof and floor of coal seams and their importance. Fireclay. Carboniferous period of the British Isles.

Cannel coal. Oil shale.

Stratified ironstone of the Coal Measures. Black band ironstone. Stratified ironstone of the Secondary rocks.

II. Prospecting.

Not taken in Stage 1.

III. Boring.

Not taken in Stage 1.

IV. Excavation.

(1.) Tools and Appliances for Excavating by Manual Labour.—Picks and shovels of various kinds. Tools for boring holes by rotation and by percussion. Wedges, simple and multiple.

Explosives and blasting. Classification of explosives. "Permitted explosives" and explosives which have passed the "Special Test." Charging shot holes. Methods of firing—Squibs ("Germans"), safety fuse, electric fuse, and other fuses for obviating sparks or flame. Miss-fires. Blown-out shots.

(2.) Excavating Work Generally.—Sinking shafts, driving levels, "getting" coal, ironstone, shale and fireclay by manual labour.

V. Supports.

(1.) Timber.—Kinds of timber used for supporting the sides of excavations. Stocking timber. Advantages of seasoning. Dry rot and its prevention by various methods. Tools and machines for preparing timber.

Modes of timbering shafts, levels and working. Single props. Prop and lid. Props and bars. Cogs or chocks. Cocker megs. Holing props or sprags.

Appliances for withdrawing timber.

(2.) Brickwork, Masonry, and Concrete.—Materials employed. Dry walling. Brick arches. Bricking shafts. Scaffolding employed when lining shafts with brickwork or masonry. Pack walls.

Concrete.—Manner in which it is made and used. Advantages and disadvantages of concrete for lining shafts and levels.

(3.) Iron and Steel.—Steel frames for shafts and levels. Various shapes and sizes.

Combination of steel and timber or steel and masonry. Steel and iron supports for working places, with or without the use of timber.

VI. Methods of Working.

Considerations determining the position of the shafts. Number, form and dimensions of the shafts. Shaft pillars. Direction of the main haulage roads, size of main road pillars.

(*a.*) Pillar workings. Early method with small pillars; difficulties arising therefrom. Size of pillars in relation to depth.

(*b.*) Longwall. Its advantages and limitations; various modifications.

VII. Haulage or Conveyance along Level or Inclined Roads.

Mine waggons ("tubs" or "corves"): Dimensions and modes of construction. Rails. Sleepers. Points. Turntables.

Animal power:—Men; horses, mules, ponies, stables, feeding.

VIII. Winding.

Machinery and appliances required. Engines. Drums. Ropes and chains of various kinds. Greasing. Examination of ropes. Attachments ("capping"). Pithead frame. Pulleys. Sinking buckets ("bowk" or "hoppet"). Cages. Permanent guides or conductors. Keps of various kinds. Onsetting. Landing or Banking.

IX. Drainage.

Pumps. Engines above and below ground. Steam pipes carried down the shaft. Transmission of power by rods, water, compressed air and electricity. Lifting pumps, force pumps, valves, columns, counter-balances and safety-catches for rods.

X. Ventilation.

Composition of air. Causes of the pollution of the air of mines: (*a*) natural gases finding their way into mines, their composition and properties; (*b*) artificial causes of the pollution of the air of mines. Modes of detection of the gases by various methods.

Natural ventilation, its disadvantages and insufficiency.

Artificial ventilation: Furnace; mechanical ventilators of various kinds.

XI. Lighting.

Candles. Lamps. Various illuminating materials employed. Safety lamps. Principle of the safety lamp. Davy lamp. Clanny, Mueseler, Marsaut, and other safety lamps.

Cleaning, filling, lighting, locking, re-lighting, and testing safety lamps.

MINING AND QUARRYING.—BRANCH B.

(Mineral workings not comprised under the Coal Mines Regulation Act.)

I. Occurrence.

The earth's crust. Stratified and unstratified rocks. Lamination or bedding. Thinning out. Principal varieties of stratified rocks. Dip and strike. Bends. Folds. Contortions. Jointing. Unconformability. Veins. Rich parts of veins. Masses. Faults of various kinds. Measurement of their throw. Rules for searching for a vein or seam beyond a fault or dislocation.

Examples of mineral deposits:—

Copper ore, iron ore, lead ore, limestone, salt, slate, tin ore, zinc ore.

II. Prospecting.

Not taken in Stage 1.

III. Boring.

Not taken in Stage 1.

IV. Excavation.

(1.) Tools and Appliances for Excavating by Manual Labour.—Picks and shovels of various kinds. Tools for boring holes by rotation and by percussion. Wedges, simple and multiple.

Explosives and blasting. Classification of explosives. Charging of shot holes. Methods of firing: squibs, safety fuse, electric fuse, and other fuses. Miss-fires. Blown-out shots.

(2.) Excavating Work Generally.—Sinking shafts, driving levels, and "getting" minerals by manual labour.

V. Supports.

(1.) Timber.—Kinds of timber used for supporting the sides of excavations. Stocking timber. Advantages of seasoning. Dry rot and its prevention by various methods. Tools and machines for preparing timber.

Modes of timbering shafts, levels, and working places. Single props, prop and lid. Props and bars. Cogs or chocks. Stulls.

Appliances for withdrawing timber.

(2.) Brickwork, Masonry, and Concrete.—Materials employed. Dry walling. Brick arches. Bricking shafts. Scaffolding employed when lining shafts with brickwork or masonry. Pack walls.

Concrete. Manner in which it is made and used. Advantages and disadvantages of concrete for lining shafts and levels.

(3.) Iron and Steel.—Steel frames for shafts and levels. Various shapes and sizes.

Combination of steel and timber or steel and masonry.

Steel and iron supports for working places, with or without the use of timber.

VI. Methods of Working.

Classification and description of methods of working:—

(1.) Subaërial or open workings, or quarries; (2.) subaqueous workings, dredging, &c.; (3.) wells and boreholes; (4.) combination of open and underground workings; (5.) underground workings.

Classification and description of methods of working underground, viz. (*a*) by permanent pillars; (*b*) by allowing the roof to fall in; (*c*) by filling up the excavations. Examples.

VII. Haulage, or Conveyance along Level or Inclined Roads.

Mine waggons; dimensions and mode of construction. Rails. Sleepers. Points. Turntables. Animal power: Men; horses, mules, ponies, stables, feeding.

VIII. Winding.

Machinery and appliances required:—Engines. Drums. Ropes and chains of various kinds. Greasing. Examination of ropes. Attachments ("capping"). Pithead frame. Pulleys. Sinking buckets ("bowk" "hoppet"). Cages. Permanent guides or conductors. Keps of various kinds. Onsetting. Landing or banking.

IX. Drainage.

Pumps. Engines above and below ground. Steam pipes carried down the shaft. Transmission of power by rods, water, compressed air and electricity. Lifting pumps, force pumps, valves, columns, counter-balances and safety-catches for rods.

X. Ventilation.

Composition of air. Causes of the pollution of the air of mines: (*a*) Natural gases finding their way into mines, their composition and properties; (*b*) artificial causes of the pollution of the air of mines. Modes of detecting the gases by various methods.

Natural ventilation, its disadvantages and insufficiency.

Artificial ventilation: Furnaces; mechanical ventilators of various kinds.

XI. Lighting.

Candles. Lamps. Various illuminating materials employed. Safety lamps. Principle of the safety lamp.

STAGE. 2.

Candidates in this stage should show some knowledge of details in their answers, and should be able to give proper sketches with dimensions when necessary in support of their written descriptions.

MINING.—BRANCH A.

(Coal, stratified ironstone, fireclay and shale.)

I. Occurrence.

The earth's crust. Stratified and unstratified rocks. Lamination or bedding. Thinning out. Principal varieties of stratified rocks. Dip and strike. Bends. Folds. Contortions. Jointing. Cleat. Unconformability. Geological epochs. Faults of various kinds. Measurement of their throw. Rules for searching for a seam beyond a fault or dislocation.

Minerals worked under the Coal Mines Regulation Act, viz., coal, stratified ironstone, shale and fireclay. Various kinds of coal, geological formations in which workable seams of coal occur. Rocks forming the roof and floor of coal seams, and their importance. Fireclay. Carboniferous period of the British Isles. Oolitic and Tertiary coal in the British Isles.

Cannel coal. Oil shale.

Stratified ironstone of the Coal Measures. Black band ironstone. Stratified ironstone of the Secondary rocks.

II. Prospecting.

Surface indications of coal, stratified ironstone, shale and fireclay. Use of geological evidence and fossils in the search. Geological maps. Extension of the Coal Measures under the Secondary rocks of this country.

III. Boring.

Not taken in Stage 2.

IV. Excavation.

(1.) Tools and Appliances for Excavating by Manual Labour.—Picks and shovels of various kinds. Tools for boring holes by rotation and by percussion. Wedges, simple and multiple.

Explosives and blasting. Classification of explosives. "Permitted explosives" and explosives which have passed the "Special Test." Charging shot holes. Methods of firing: Squibs ("Germans"), safety fuse, electric fuse, and other fuses for obviating sparks or flame. Miss-fires. Blown-out shots.

(2.) Machines Used for Excavating.—Transmission of power from the surface into underground workings by water, compressed air and electricity. Advantages and disadvantages of each of the three systems.

Excavating machines, viz.:—(*a*) Percussive and rotary machine drills. (*b*) Coal-cutting machines of various types, viz.: mechanical chisels, circular saws or disc-machines, endless chains, revolving bars. (*c*) Tunnelling or "heading" machines, shaft-sinking machines.

Amount of work done by machines compared with hand labour. Advantages and disadvantages of each type of machine.

(3.) Excavating Work Generally.—Sinking shafts, driving levels, "getting" coal, ironstone, shale and fireclay.

V. Supports.

(1.) Timber.—Kinds of timber used for supporting the sides of excavations. Stocking timber. Advantages of seasoning. Dry rot and its prevention by various methods. Tools and machines for preparing timber.

Modes of timbering shafts, levels and working places. Single prop[illegible]s. Prop and Lid. Props and bars. Cogs or chocks. Cocker megs. Holin[illegible]g props or sprags.

Appliances for withdrawing timber.

(2.) BRICKWORK, MASONRY, AND CONCRETE.—Materials employed. Dr[illegible]ry walling. Brick arches. Bricking shafts. Scaffolding employed whe[illegible]en lining shafts with brickwork or masonry. Pack walls.

Concrete.—Manner in which it is made and used. Advantages an[illegible]nd disadvantages of concrete for lining shafts and levels.

(3.) IRON AND STEEL.—Steel frames for shafts and levels. Various shape[illegible]pes and sizes.

Combination of steel and timber or steel and masonry. Steel and iro[illegible]on supports for working places, with or without the use of timber.

(4.) SPECIAL SUPPORTING PROCESSES FOR LOOSE, WATERY, OR RUNNIN[illegible]N STRATA :—

(*a*) "Spilling," "piling," or "forepoling."
(*b*) Sinking linings.
(*c*) Coffering.
(*d*) Tubbing.
(*e*) Sinking by aid of compressed air.
(*f*) Poetsch or freezing process.
(*g*) Various boring processes with special linings.

VI. METHODS OF WORKING.

Considerations determining the position of the shafts. Number, for[illegible]m and dimensions of the shafts. Shaft pillars. Direction of the mai[illegible]a haulage roads, size of main road pillars.

(*a*) Pillar workings. Early method with small pillars; difficultie[illegible]ti arising therefrom. Size of pillars in relation to depth.

(*b*) Longwall. Its advantages and limitations; various modifications.

(*c*) Special cases of highly inclined or very thick seams.

VII. HAULAGE OR CONVEYANCE ALONG LEVEL OR INCLINED ROADS.

Mine waggons ("tubs" or "corves"): Dimensions and modes of con[illegible]on- struction. Rails. Sleepers. Points. Turntables. Calculations as t[illegible]to gradient, resistances and power required. Animal power: Men; horse[illegible]es, mules, ponies, stables, feeding. Mechanical power. Various systems o[illegible]of mechanical rope and chain haulage.

Electric railways: Compressed air locomotives.

Self-acting inclined planes for various degrees of inclination. Incline[illegible]d planes with winding engines ("Engine planes").

Signalling.

Aërial ropeways.

VIII. WINDING.

Machinery and appliances required:—Engines. Drums. Ropes an[illegible]d chains of various kinds. Breaking strains and working loads of rope[illegible]s and chains. Testing wire ropes. Causes of deterioration of ropes an[illegible] remedies. Greasing. Examination of ropes. Attachments ("capping") [illegible] Pithead frame. Pulleys. Sinking buckets ("bowk" or "hoppet"). Cages [illegible] Temporary guides for sinking shafts. Permanent guides or conductors [illegible] Keps of various kinds. Onsetting. Landing or Banking. Indicators [illegible] Signals. Speed-indicators. Speed-checking appliances. Detaching hooks [illegible]

Methods of equalizing the load: Koepe and other systems.

IX.—DRAINAGE.

Sources of water met with in mines. Prevention of influx of surface water. Dams of timber, brick and concrete. Drainage tunnels. Siphons Winding water by buckets or tanks, and modes of filling and discharging them.

Pumps. Engines above and below ground. Steam pipes carried down the shaft. Transmission of power by rods, water, compressed air and electricity. Lifting pumps, force pumps, valves, columns, counter-balances, and safety-catches for rods. Ordinary electric pumps, quick-running electric pumps.

Centrifugal pumps; pulsometer; special pumps for sinking purposes.

Corrosive water. Duty of pumping engines.

Co-operative drainage.

X. Ventilation.

Composition of air. Causes of the pollution of the air of mines: (*a*) Natural gases finding their way into mines, their composition and properties. (*b*) Artificial causes of the pollution of the air of mines. Modes of detection of the gases by various methods, and determination of their amount in mine air.

Natural ventilation, its disadvantages and insufficiency.

Artificial ventilation: Furnace; mechanical ventilators of various kinds. Calculations as to quantity, pressure, and power. Distribution of the air through the workings. Friction of air currents. Equivalent orifice. "Splitting" of air. Thermometer and barometer. Methods of measuring and recording the volume of air passing through the workings. Anemometers. Water gauges. Quantity of air required.

XI. Lighting.

Candles. Lamps. Various illuminating materials employed. Safety lamps. Principle of the safety lamp. Davy lamp. Clanny, Mueseler, Marsaut, and other safety lamps.

Cleaning, filling, lighting, locking, re-lighting and testing safety lamps.

Stationary electric lamps for the surface and for pit-bottoms. Electric lamps for sinking pits. Portable electric lamps for working places.

Acetylene lamps.

XII. Descent and Ascent.

Ladders. Bucket. Man-engine. Cage.

XIII. Preparation of the Minerals for the Market.

Tipplers. Screening and picking. Conveyors.

Coal washing.

MINING AND QUARRYING.—BRANCH B.

(Mineral workings not comprised under the Coal Mines Regulation Act.)

I. Occurrence.

The earth's crust. Stratified and unstratified rocks. Lamination or bedding. Thinning out. Principal varieties of stratified rocks. Dip and strike. Bends. Folds. Contortions. Jointing. Unconformability. Veins. Rich parts of veins. Masses. Faults of various kinds. Measurement of their throw. Rules for searching for a vein or seam beyond a fault or dislocation.

Examples of mineral deposits:—Asphalt, barytes, chalk, clay, copper ore, gold ore, granite, graphite, gypsum, iron ore, iron pyrites, lead ore, limestone, phosphate of lime, potassium salts, quicksilver ore salt, sand, sandstone, silver ore, slate, sulphur, tin ore, zinc ore.

II. Prospecting.

Aid afforded by geology; evidence given by fossils. Associated minerals. Surface indications: (*a*) form of the ground; (*b*) mineral exposed in natural or artificial cuttings; (*c*) loose fragments lying about on the surface; (*d*) pieces thrown out by burrowing animals; (*e*) ordinary springs, mineral springs, gaseous emanations, warmth; (*f*) colour; (*g*) decomposed outcrop, gossan; (*h*) indicative plants and animals; (*i*) altered vegetation; (*j*) old working, slag heaps, ruins, names of places; old records.

Methods of seeking or discovering deposits: (*a*) shoading and loaming; (*b*) probing; (*c*) boring; (*d*) trenching; (*e*) hushing; (*f*) sinking small shafts; (*g*) dipping needle.

Difficulties which beset the prospector.

Qualifications which are necessary or desirable for successful prospecting.

III. Boring.

Not taken in Stage 2.

IV. Excavation.

(1.) Tools and Appliances for Excavating by Manual Labour.—Picks and shovels of various kinds. Tools for boring holes by rotation and by percussion. Wedges, simple and multiple.

Explosives and blasting. Classification of explosives. Charging shot holes. Methods of firing: Squibs, safety fuse, electric fuse, and other fuses. Miss-fires. Blown-out shots.

(2.) Machines used for Excavating.—Transmission of power from the surface into underground workings by water, compressed air and electricity. Advantages and disadvantages of each of the three systems.

Excavating machines, viz:—(*a*) Diggers and dredgers; (*b*) Percussive and rotatory rock drills; (*c*) groove-cutting machines of various types, viz.: mechanical chisels, circular saws or disc-machines, endless chains, revolving bars, wire-saw; (*d*) tunnelling and shaft-sinking machines.

Amount of work done by machines compared with hand labour. Advantages and disadvantages of each type of machine.

(3.) Excavation by Jet of Water (hydraulic mining).

(4.) Excavation by Solution.

(5.) Excavating Work Generally.

Sinking shafts, driving levels, "getting" minerals in various ways.

V. Supports.

(1.) Timber.—Kinds of timber used for supporting the sides of excavations. Stocking timber. Advantages of seasoning. Dry rot and its prevention by various methods. Tools and machines for preparing timber.

Modes of timbering shafts, levels, and working places. Single props. Prop and lid. Props and bars. Cogs or chocks. Stulls.

Appliances for withdrawing timber.

(2.) Brickwork, Masonry, and Concrete.—Materials employed. Dry walling. Brick arches. Bricking shafts. Scaffolding employed when lining shafts with brickwork or masonry. Pack walls.

Concrete.—Manner in which it is made and used. Advantages and disadvantages of concrete for lining shafts and levels.

(3.) Iron and Steel.—Steel frames for shafts and levels. Various shapes and sizes.

Combination of steel and timber or steel and masonry.

Steel and iron supports for working places, with or without the use of timber.

(4.) Special Supporting Processes for Loose, Watery, or Running Strata:—

(*a*) "Spilling," "piling" or "forepoling."
(*b*) Coffering.
(*c*) Sinking linings.
(*d*) Tubbing.
(*e*) Sinking by aid of compressed air.
(*f*) Poetsch or freezing process.
(*g*) Various boring processes with special linings.

VI. Methods of Working.

Classification and description of methods of working: (1) Subaërial or open workings, or quarries; (2) subaqueous workings, dredging &c.; (3) wells and boreholes; (4) combination of open and underground workings; (5) underground workings.

Classification and description of methods of working underground, viz.: (*a*) by permanent pillars; (*b*) by allowing the roof to fall in; (*c*) by filling up the excavations. Examples.

VII. Haulage, or Conveyance along Level or Inclined Roads.

Mine waggons: dimensions and mode of construction. Rails. Sleepers. Points. Turntables. Calculations as to gradient, resistances and power required. Animal power: Men; horses, mules, ponies, stables, feeding. Mechanical power. Various systems of mechanical rope and chain haulage.

Electric railways. Compressed air locomotives. Self-acting inclined planes for various degrees of inclination. Inclined planes with winding engines ("Engine planes").

Signalling.

Aërial ropeways.

VIII. Winding.

Machinery and appliances required:—Engines. Drums. Ropes and chains of various kinds. Breaking strains and working loads of ropes and chains. Testing wire ropes. Causes of deterioration of ropes, and remedies. Greasing. Examination of ropes. Attachment ("capping"). Pithead frame. Pulleys. Sinking buckets ("bowk" or "hoppet"). Cages. Temporary guides for sinking shafts. Permanent guides or conductors. Keps of various kinds. Onsetting. Landing or banking. Indicators. Signals. Speed indicators. Speed-checking appliances. Detaching hooks.

Methods of equalising the load. Koepe and other systems.

IX. Drainage

Sources of water met with in mines. Prevention of influx of surface water. Dams of timber, brick, and concrete. Drainage tunnels. Siphons. Winding water by buckets or tanks, and modes of filling and discharging them.

Pumps. Engines above and below ground. Steam pipes carried down the shaft. Transmission of power by rods, water, compressed air and electricity. Lifting pumps, force pumps, valves, columns, counter-balances and safety-catches for rods. Ordinary electric pumps, quick-running electric pumps.

Centrifugal pumps; pulsometer; special pumps for sinking purposes.

Corrosive water. Duty of pumping engines.

Co-operative drainage.

X. Ventilation.

Composition of air. Causes of the pollution of the air of mines; (*a*) Natural gases finding their way into mines, their composition and properties: (*b*) artificial causes of the pollution of the air of mines. Modes of detection of the gases by various methods and determination of their amount in mine air.

Natural ventilation, its disadvantages and insufficiency.

Artificial ventilation: Furnace; mechanical ventilators of various kinds. Calculations as to quantity, pressure, and power. Distribution of the air through the workings. Friction of air currents. "Splitting" of air. Methods of measuring and recording the volume of air passing through the workings. Anemometers. Water gauges. Quantity of air required.

XI. Lighting.

Candles. Lamps. Various illuminating materials employed. Safety lamps. Principle of the safety lamp.

Stationary electric lamps for the surface and for pit-bottoms. Electric lamps for sinking pits. Portable electric lamps for working places.
Acetylene lamps.

XII. Descent and Ascent.

Steps and slides. Ladders. Bucket. Cage. Man-engine.

XIII. Dressing.

(1.) Mechanical processes. Washing, picking, breaking up by hand, rock-breakers, crushers, stamps, &c.

(2.) Processes depending upon physical properties: motion in water, motion in air, liquefaction and distillation, magnetic attraction, surface adhesion.

(3.) Processes depending upon chemical properties.
Examples of the methods of preparing ores and stones for the market. Sampling.

STAGE 3.

Candidates in this stage should show decided knowledge of details in the answers, and should be able to give proper sketches with dimensions where necessary in support of their written descriptions. They should be able to discuss the methods of occurrence and working of minerals in some district (of their own knowledge), and also be generally familiar with those of other districts from study. The constructive details of the machinery and engineering works of mines should also be studied in addition to the general principles. Exactness will be expected in all that relates to numbers, dimensions, and weights, and as neat and accurate drawing as the time will permit.

MINING.—BRANCH A.

(Coal, stratified ironstone, fireclay and shale.)

I. Occurrence.

The earth's crust. Stratified and unstratified rocks. Lamination or bedding. Thinning out. Principal varieties of stratified rocks. Dip and strike. Bends. Folds. Contortions. Jointing. Cleat. Unconformability. Geological epochs. Faults of various kinds. Measurement of their throw. Rules for searching for a seam beyond a fault or dislocation.

Minerals worked under the Coal Mines Regulation Act, viz., coal, stratified ironstone, shale and fireclay. Various kinds of coal, geological formations in which workable seams of coal occur. Rocks forming the roof and floor of coal seams, and their importance. Fireclay. Carboniferous period of the British Isles. Oolitic and Tertiary coal in the British Isles. Coal-bearing rocks of the principal British Colonies and foreign countries.

Cannel coal. Oil shale.

Stratified ironstone of the Coal Measures. Black band ironstone.
Stratified ironstone of the Secondary rocks.

II. Prospecting.

Surface indications of coal, stratified ironstone, shale and fireclay. Use of geological evidence and fossils in the search. Geological maps. Extension of the Coal Measures under the Secondary rocks of this country.

III. Boring.

Methods. Percussive boring by rods and by rope.
Diamond and steel crowns. Tubing boreholes.
Methods of cutting them and extracting them.
Dip and strike.

IV. Excavation.

s and Appliances for Excavating by Manual Labour.—novels of various kinds. Tools for boring holes by rotation and on. Wedges, simple and multiple.
es and blasting. Classification of explosives. "Permitted" and explosives which have passed the "Special Test." Charging Methods of firing: Squibs ("Germans"), safety fuse, electric ther fuses for obviating sparks or flame. Miss-fires. Blown-out

chines Used for Excavating.—Transmission of power from the to underground workings by water, compressed air and electricity. ges and disadvantages of each of the three systems.
ication and description of excavating machines, viz.:—(*a*) Per- and rotary machine drills. (*b*) Coal-cutting machines of various iz.: mechanical chisels, circular saws or disc-machines, endless evolving bars. (*c*) Tunnelling or "heading" machines, shaft-sinking s.
unt of work done by machines compared with hand labour. ages and disadvantages of each type of machine.

Excavating Work Generally.—Sinking shafts, driving levels, ng" coal, ironstone, shale and fireclay.

V. Supports.

Timber.—Kinds of timber used for supporting the sides of excava-. Stocking timber. Advantages of seasoning. Dry rot and its ention by various methods. Tools and machines for preparing er.

odes of timbering shafts, levels and working places. Single props. and Lid. Props and bars. Cogs or chocks. Cocker megs. Holing es or sprags.
ppliances for withdrawing timber.

.) Brickwork, Masonry, and Concrete.—Materials employed. Dry ling. Brick arches. Bricking shafts. Scaffolding employed when ng shafts with brickwork or masonry. Pack walls.
oncrete.—Manner in which it is made and used. Advantages and dvantages of concrete for lining shafts and levels.

.) Iron and Steel.—Steel frames for shafts and levels. Various shapes sizes.
ombination of steel and timber or steel and masonry. Steel and iron ports for working places, with or without the use of timber.

.) Special Supporting Processes for Loose, Watery, or Running ata:—
(*a*) "Spilling," "piling," or "forepoling."
(*b*) Sinking linings.
(*c*) Coffering.
(*d*) Tubbing.
(*e*) Sinking by aid of compressed air.
(*f*) Poetsch or freezing process.
(*g*) Various boring processes with special linings.

VI. Methods of Working.

onsiderations determining the position of the shafts. Number, form dimensions of the shafts. Shaft pillars. Direction of the main lage roads, size of main road pillars.
.) Pillar workings. Early method with small pillars; difficulties ing therefrom. Size of pillars in relation to depth.
.) Longwall. Its advantages and limitations; various modifications.
.) Special cases of highly inclined or very thick seams.

VII. HAULAGE OR CONVEYANCE ALONG LEVEL OR INCLINED ROAD.

Mine waggons "tubs" or "corves". Dimensions and modes of construction. Rails. Sleepers. Points. Turntables. Calculations as to gradient, resistances and power required. Animal power: Men: horses, mules, ponies, donkeys, leering. Mechanical power, various systems of mechanical rope and chain haulage.

Electric railways. Compressed air locomotives.

Self-acting inclined planes for various degrees of inclination. Inclined planes with winding engine "Engine planes".

Signaling.

Aerial ropeways.

VIII. WINDING.

Machinery and appliances required.—Engines. Drums. Ropes and chains of various kinds. Breaking strains and working loads of ropes and chains. Testing wire ropes. Causes of deterioration of ropes and remedies. Greasing. Examination of ropes. Attachments ("capping"). Pithead frame. Pulleys. Sinking buckets ("bowk" or "hoppet"). Cages. Temporary guides for sinking shafts. Permanent guides or conductors. Keps of various kinds. Onsetting. Landing or Banking. Indicators. Signals. Speed-indicators. Speed-checking appliances. Detaching hooks.

Methods of equalizing the load. Koepe and other systems.

IX.—DRAINAGE.

Sources of water met with in mines. Prevention of influx of surface water. Dams of timber, brick and concrete. Drainage tunnels. Siphons. Winding water by buckets or tanks, and modes of filling and discharging them.

Pumps. Engines above and below ground. Steam pipe carried down the shaft. Transmission of power by rods, water, compressed air, electricity. Lifting pumps, force pumps, valves, columns, counter-balances and safety-catches for rods. Ordinary electric pumps, quick-running electric pumps.

Centrifugal pumps: pulsometer; special pumps for sinking purposes.

Corrosive water. Duty of pumping engines.

Co-operative drainage.

X. VENTILATION.

Composition of air. Causes of the pollution of the air of mines; (a) Natural gases finding their way into mines, their composition and properties. (b) Artificial causes of the pollution of the air of mines. Modes of detection of the gases by various methods, and determination of their amount in mine air.

Natural ventilation, its disadvantages and insufficiency.

Artificial ventilation: Furnace; mechanical ventilators of various kinds. Calculations as to quantity, pressure and power. Distribution of the air through the workings. Friction of air currents. Equivalent orifice. "Splitting" of air. Thermometer and barometer. Methods of measuring and recording the volume of air passing through the workings. Anemometers. Water gauges. Quantity of air required.

XI. LIGHTING.

Candles. Lamps. Various illuminating materials employed. Safety lamps. Principle of the safety lamp. Davy lamp. Clanny, Muesler, Marsaut, and other safety lamps.

Cleaning, filling, lighting, locking, re-lighting and testing safety lamps.

Stationary electric lamps for the surface and for pit-bottoms. Electric lamps for sinking pits. Portable electric lamps for working places.

Acetylene lamps.

XII. Descent and Ascent.

Ladders. Bucket. Man-engine. Cage.

XIII. Preparation of the Minerals for the Market.

Tipplers. Screening and picking. Conveyors.

Coal washing.

Coking. Nature of coking coals. Coking coals in heaps, bee-hive ovens, retort ovens with or without recovery of bye-products; mechanical discharge of coke-ovens.

Manufacture of briquettes or patent fuel.

Calcination of iron ore.

Loading coal into railway trucks, barges and ships.

XIV. Legislation.

Classification of mineral workings in the United Kingdom.

Special Acts of Parliament regulating the working of minerals in the United Kingdom: Coal Mines Regulation Acts, Metalliferous Mines Regulation Acts and Quarries Act. Principal provisions of the Coal Mines Regulation Acts. General Rules. Special Rules. Truck Acts. Workmen's Compensation Act.

XV. Condition of the Workmen.

Foods and clothing. Houses. Barracks. Provident Societies. Health and diseases of the miner. Comparison with other trades. Hospitals. Amusements. Education.

XVI. Accidents and their Prevention.

Standards by which the danger or safety of the miner's calling may be gauged. Death-rates from accidents per 1,000 persons employed. Comparison with other industries. Death-rates per million tons of mineral raised. Comparison of both kinds of British death-rates with those of other countries.

Classification of accidents according to the scheme in the Reports of the British Inspectors of Mines.

Average proportions of the total number of deaths due to each respective cause. Special stress laid upon the accidents from falls of roof and side. Means of preventing each class of accidents.

Necessity of treatment of the injured on the spot.* Rescue of persons after an explosion or an underground fire.

MINING AND QUARRYING.—BRANCH B.

(Mineral workings not comprised under the Coal Mines Regulation Act.)

I. Occurrence.

The earth's crust. Stratified and unstratified rocks. Lamination of bedding. Thinning out. Principle varieties of stratified rocks. Dip and strike. Bends. Folds. Contortions. Jointings. Unconformability. Veins. Rich parts of veins. Masses. Faults of various kinds. Measurement of their throw. Rules for searching for a vein or seam beyond a fault or dislocation.

Examples of mineral deposits:—Alumstone, amber, antimony ore, arsenical ores, asbestos, asphalt, barytes, borax, boric acid, carbonic acid, chalk, clay, cobalt ore, copper ore, flint, freestone, gold ore, granite, graphite, gypsum, iron ore, iron pyrites, lead ore, limestone, manganese ore, mica, natural gas, nickel ore, nitrate of soda, ozokerite, petroleum, phosphate of lime, potassium salts, quicksilver ore, salt, sand, sandstone, silver ore, slate, sulphur, tin ore, zinc ore.

* The subject of "First aid to the Injured" should be dealt with by the Ambulance Lecturer, and not by the Mining Lecturer.

II. Prospecting.

Aid afforded by geology; evidence given by fossils. Associated minerals. Surface indications: (*a*) form of the ground; (*b*) mineral exposed in natural or artificial cuttings; (*c*) loose fragments lying about on the surface; (*d*) pieces thrown out by burrowing animals; (*e*) ordinary springs, mineral springs, gaseous emanations, warmth; (*f*) colour; (*g*) decomposed outcrop, gossan; (*h*) indicative plants and animals; (*i*) altered vegetation; (*j*) old working, slag heaps, ruins, names of places; old records.

Methods of seeking or discovering deposits; (*a*) shoading and loaming; (*b*) probing; (*c*) boring (*d*) trenching; (*e*) hushing; (*f*) sinking small shafts; (*g*) dipping needle.

Difficulties which beset the prospector.

Qualifications which are necessary or desirable for successful prospecting.

III. Boring.

Boring by various methods. Percussive boring by rods and rope. Rotatory boring with diamond and steel crowns. Tubing boreholes. Accidents to tools. Cores; methods of cutting them and extracting them. Methods of ascertaining the true dip and strike.

IV. Excavation.

(1.) Tools and Appliances for Excavating by Manual Labour.—Picks and shovels of various kinds. Tools for boring holes by rotation and by percussion. Wedges, simple and multiple.

Explosives and blasting. Classification of explosives. Charging shot holes. Methods of firing: Squibs, safety fuse, electric fuse, and other fuses. Miss-fires. Blown-out shots.

(2.) Machines used for Excavating.—Transmission of power from the surface into underground workings by water, compressed air and electricity. Advantages and disadvantages of each of the three systems.

Classification and description of excavating machines, viz:—

(*a*) Diggers and dredgers; (*b*) Percussive and rotatory rock drills; (*c*) groove-cutting machines of various types, viz.: mechanical chisels, circular saws or disc-machines, endless chains, revolving bars, wire-saw; (*d*) tunnelling and shaft-sinking machines.

Amount of work done by machines compared with hand labour. Advantages and disadvantages of each type of machine.

(3.) Excavation by Jet of Water (hydraulic mining).

(4.) Excavation by Solution.

(5.) Excavating Work Generally.

Sinking shafts, driving levels, "getting" minerals in various ways.

V. Supports.

(1.) Timber.—Kinds of timber used for supporting the sides of excavations. Stocking timber. Advantages of seasoning. Dry rot and its prevention by various methods. Tools and machines for preparing timber.

Modes of timbering shafts, levels, and working places. Single props. Prop and lid. Props and bars. Cogs or chocks. Stulls.

Appliances for withdrawing timber.

(2.) Brickwork, Masonry, and Concrete.—Materials employed. Dry walling. Brick arches. Bricking shafts. Scaffolding employed when lining shafts with brickwork or masonry. Pack walls.

Concrete.—Manner in which it is made and used. Advantages and disadvantages of concrete for lining shafts and levels.

(3.) Iron and Steel.—Steel frames for shafts and levels. Various shapes and sizes.

Combination of steel and timber or steel and masonry.
Steel and iron supports for working places, with or without the use of timber.

(4) SPECIAL SUPPORTING PROCESSES FOR LOOSE, WATERY, OR RUNNING STRATA :—
(*a*) "Spilling," "piling," or "forepoling."
(*b*) Coffering.
(*c*) Sinking linings.
(*d*) Tubbing.
(*e*) Sinking by aid of compressed air.
(*f*) Poetsch or freezing process.
(*g*) Various boring processes with special linings.

VI. METHODS OF WORKING.

Classification and description of methods of working: (1) Subaërial or open workings or quarries; (2) subaqueous workings, dredging, etc.; (3) wells and bore-holes; (4) combination of open and underground workings; (5) underground workings.
Classification and description of methods of working underground, viz.: (*a*) by permanent pillars; (*b*) by allowing the roof to fall in; (*c*) by filling up the excavations. Examples.

VII. HAULAGE, OR CONVEYANCE ALONG LEVEL OR INCLINED ROADS.

Mine waggons; dimensions and mode of construction. Rails. Sleepers. Points. Turntables. Calculations as to gradient, resistances, and power required. Animal power: Men; horses, mules, ponies, stables, feeding. Mechanical power: Various systems of mechanical rope and chain haulage.
Electric railways. Compressed air locomotives. Self-acting inclined planes for various degrees of inclination. Inclined planes with winding engines ("Engine planes").
Signalling.
Aërial ropeways.

VIII. WINDING.

Machinery and appliances required:—Engines. Drums. Ropes and chains of various kinds. Breaking strains and working loads of ropes and chains. Testing wire ropes. Causes of deterioration of ropes, and remedies. Greasing. Examination of ropes. Attachment ("capping"). Pithead frame. Pulleys. Sinking buckets ("bowk" or "hoppet"). Cages. Temporary guides for sinking shafts. Permanent guides or conductors. Keps of various kinds. Onsetting. Landing or banking. Indicators. Signals. Speed indicators. Speed-checking appliances. Detaching hooks.
Methods of equalising the load. Koepe and other systems.

IX. DRAINAGE.

Sources of water met with in mines. Prevention of influx of surface water. Dams of timber, brick, and concrete. Drainage tunnels. Siphons. Winding water by buckets or tanks, and modes of filling and discharging them.
Pumps. Engines above and below ground. Steam pipes carried down the shaft. Transmission of power by rods, water, compressed air and electricity. Lifting pumps, force pumps, valves, columns, counter-balances and safety-catches for rods. Ordinary electric pumps, quick-running electric pumps.
Centrifugal pumps; pulsometer; special pumps for sinking purposes.
Corrosive water. Duty of pumping engines.
Co-operative drainage.

X. Ventilation.

Composition of air. Causes of the pollution of the air of mines; (*a*) Natural gases finding their way into mines, their composition and properties; (*b*) artificial causes of the pollution of the air of mines. Modes of detection of the gases by various methods and determination of their amount in mine air.

Natural ventilation, its disadvantages and insufficiency.

Artificial ventilation; Furnace; mechanical ventilators of various kinds. Calculations as to quantity, pressure, and power. Distribution of the air through the workings. Friction of air currents. "Splitting" of air. Methods of measuring and recording the volume of air passing through the workings. Anemometers. Water gauges. Quantity of air required.

XI. Lighting.

Candles. Lamps. Various illuminating materials employed. Safety lamps. Principle of the safety lamp. Davy lamp, Clanny, Mueseler, Marsaut, and other safety lamps.

Cleaning, filling, lighting, locking, relighting, and testing safety lamps.

Stationary electric lamps for the surface and for pit-bottoms. Electric lamps for sinking pits. Portable electric lamps for working places.

Acetylene lamps.

XII. Descent and Ascent.

Steps and slides. Ladders. Bucket. Cage. Man-engine.

XIII. Dressing.

(1.) Mechanical processes. Washing, picking, breaking up by hand, rock-breakers, crushers, stamps, etc.

(2.) Processes depending upon physical properties: motion in water, motion in air, liquefaction and distillation, magnetic attraction, surface adhesion.

(3.) Processes depending upon chemical properties.

Examples of the methods of preparing ores and stones for the market. Sampling.

XIV. Legislation.

Classification of mineral workings in the United Kingdom.

Special Acts of Parliament regulating the working of minerals in the United Kingdom:—Coal Mines Regulation Acts, Metalliferous Mines Regulation Acts Quarries Act, Principal provisions of the Metalliferous Mines Regulation Acts and difference between them and those of the Coal Mines Regulations Acts. General Rules. Special Rules. Factory and Workshop Acts. Truck Acts. Workmen's Compensation Act.

XV. Condition of the Workmen.

Food and clothing. Houses. Barracks. Provident Societies. Health and diseases of the miner. Comparison with other trades. Hospitals. Amusements. Education.

XVI. Accidents and their Prevention.

Standards by which the danger or safety of the miner's calling may be gauged. Death-rates from accidents per 1000 persons employed. Comparison with other industries. Death-rates per million tons of mineral raised. Comparison of both kinds of British death-rates with those of other countries.

Classification of accidents according to the scheme in the Reports of the British Inspectors of Mines.

Average proportions of the total number of deaths due to each respective cause. Special stress laid upon the accidents from falls of roof and side. Means of preventing each class of accidents.

Necessity of treatment of the injured on the spot.* Rescue of persons after an explosion or an underground fire.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.)

As this examination is intended for testing the results of advanced study, the questions will be of such a nature as to admit of considerable detail in answering. Candidates will be expected to show a knowledge of the structure and working details of some of the coal-fields and ore mining districts of the United Kingdom, and of the more important ones of foreign countries; to be able to discuss and illustrate the details of different classes of mining machinery such as those for pumping, winding, and ventilation; the laying out, working, and management of coal and metal mines with details of working staff and economic arrangement, and the details of dressing machinery and plant required for treating particular qualities of stuff.

In order to secure a pass in Honours the answers must be very full and complete and the figures carefully and correctly drawn.

The examination will be conducted upon the basis of the Syllabus for Stage 3, and will include questions in Branches A and B.

Candidates are recommended to supplement their class instruction by the study of special memoirs on particular mineral districts, mines, and methods of working that have appeared in the Transactions of the various Mining Institutes.

SUBJECT XIX.—METALLURGY, THEORETICAL.

The examination paper will be divided into four sections:

1. Introductory Subjects, Refractory Materials and Fuel.
2. Iron and Steel.
3. Gold, Silver, Lead, Mercury, and Platinum.
4. Copper, Zinc, Tin, Nickel, Cobalt, Aluminium, Antimony, Arsenic, and Bismuth.

For a Second class in Stage 1 or a Second class in Stage 2, the student will only be expected to answer questions in TWO sections, of which Section 1 (Introductory Subjects, Refractory Materials and Fuel) must be one. In order to obtain a First class in Stage 1 or a First class in Stage 2, the candidate must answer questions in at least THREE sections, of which Section 1 (Introductory Subjects, Refractory Materials, and Fuel) must be one. The answering in one of these selected sections need only be such as to show a general elementary knowledge of that section.

In Stages 2 and 3 and in Honours unlabelled specimens of metals, ores, and metallurgical materials and products will be placed before the candidate for recognition and description.

NOTE.—A collection of common ores and minerals, not cabinet specimens, but such as are usually met with in metallurgical practice, and of metals, alloys, refractory and other materials, and metallurgical products should be provided at schools for the use of students.

All candidates should be able to make rough but trustworthy sectional drawings and sketches of furnaces and metallurgical appliances.

Compulsory questions may be set at the examination.

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* The subject of "First Aid to the Injured" should be dealt with by the Ambulance Lecturer, and not by the Mining Lecturer.

STAGE 1.

The candidate will be expected to possess sufficient knowledge of the chemical and physical properties of the common metals to enable him to understand the chief chemical reactions, and the principles on which the processes for the extraction and purification of these metals, and their applications to industrial purposes, are based. Only a general acquaintance with the forms and construction of the most important typical furnaces and appliances, with the modes of conducting the processes in which they are used, and with the nature of the products obtained, will be required. Questions will also be set on the approximate composition, the physical properties, and the uses of the common alloys of the metals.

The examination will consist of one written paper.

SECTION I.

INTRODUCTORY SUBJECTS, REFRACTORY MATERIALS AND FUEL.

Physical Properties of Metals and Alloys.—Specific Gravity. Varieties of Fracture. Malleability. Ductility. Extensibility. Elasticity. Tenacity. Toughness. Softness. Fusibility. Characteristic examples of these properties.

Explanation of the terms—Ore, "native," veinstuff or gangue, "dressing." Calcination. Roasting. Smelting. Refining. Matte. Regulus. Speise. Reduction. Distillation. Sublimation. Liquation. Amalgamation. Scorification. Cupellation. Annealing. Welding.

General properties of Slags and Fluxes. Approximate composition and chief characters of ordinary Slags.

Refractory Materials employed in the Construction of Furnaces, Crucibles and Retorts. Their general properties. Fire Bricks. Clay and plumbago crucibles.

Classification of furnaces.—Modes of producing and utilizing heat in the chief types of each class of furnace.

Classification of fuel.

Coal.—Characters, average composition, and uses of the various kinds. Charcoal burning.

Coke.—Properties and approximate composition of coke. General principles concerning the preparation of coke. Methods of preparing coke. Coke ovens. Construction and mode of working bee-hive, Coppee and Simon-Carvès ovens.

SECTION II.

IRON AND STEEL.

IRON.—Physical properties of iron. "Burnt iron." "Red and cold shortness." Welding.

General effects of carbon on the physical properties of iron.

Ores of iron.—Their characters and chemical composition.

General principles and chief chemical reactions on which the extraction of iron from its ores depends.

Direct production of wrought iron. Catalan process.

Indirect production of wrought iron.—Preparation of ores for smelting. Calcining kilns. Objects of calcination.

Construction of modern blast furnaces. Appliances for charging. Modes of taking off the gases. Twyers.

Simple forms of hot blast stoves.

Mode of working a blast furnace. Nature of the products—cast iron slags, furnace gases.

Utilization of the gases.

Classification of pig iron. Properties and approximate composition of the chief kinds.

Modern puddling or "pig-boiling" process. The furnace (with coal as fuel). Fettling. Working a charge. Principles of the process.

Production of puddled bars and of merchant or finished iron. Appliances used. Re-heating furnace (with coal as fuel).

STEEL.—Physical properties of steel.

Classification of processes for the production of steel. Principles and chemical reactions on which the processes are based.

The cementation process. Furnace and materials used. Blister steel. Shear steel.

Crucible steel:—Production from "converted" or "cemented" bars, and from "unconverted" bars. Furnaces (with coke as fuel) and crucibles used.

The Bessemer process. Converters and appliances used. Acid and basic linings. Nature of the products.

The acid and basic open hearth processes. Furnaces and linings used. Nature of the products.

SECTION III.

GOLD, SILVER, LEAD, MERCURY.

GOLD.—Physical properties. Precipitation of gold from solutions of its chloride.

General nature of gold ores.

Classification of processes for the extraction of gold from its ores. Principles and chemical reactions involved in the operations.

Extraction of gold from quartz in a stamp battery. Chief parts of the plant. Products. Collection and treatment of amalgam. Retort furnace.

The Plattner chlorination process. Simple roasting furnaces. Chlorination and precipitation vats.

Refining and parting gold bullion. Principles on which the operations depend. Parting by sulphuric acid. Apparatus used. Miller's chlorine process.

SILVER.—Physical properties. Solvents used for silver chloride in metallurgical processes. Methods of separating the silver from these solutions and from precipitated or fused silver chloride.

Ores of silver.

The principles and chief chemical reactions on which the processes for the extraction of silver from its ores are based.

Method of smelting silver ores associated with lead ores, or with the addition of lead ores. The smelting furnace used. Nature and treatment of the products.

Sulphating roasting of argentiferous mattes. Chloridising roasting of argentiferous ores and mattes. Simple reverberatory furnaces used in these processes.

The extraction of silver from its ores by amalgamation in pans. Appliances used. Treatment of the amalgam.

Outlines of the Ziervogel and the Augustin processes. The apparatus and appliances used in the operations.

LEAD.—Physical properties.

Lead oxide (litharge). Mode of formation by dry methods. Fusibility with other metallic oxides.

Ores of lead. Their characters and chemical composition.

The principles and chemical reactions on which the processes of smelting and purifying lead are based.

Smelting in the Flintshire furnace. The furnace used. Nature of the products.

Smelting in the shaft furnace. Roasting furnace for preparing the ore. The water-jacketed smelting furnace. Nature of the products.

Stationary electric lamps for the surface and for pit-bottoms. Electric lamps for sinking pits. Portable electric lamps for working places.
Acetylene lamps.

XII. Descent and Ascent.

Steps and slides. Ladders. Bucket. Cage. Man-engine.

XIII. Dressing.

(1.) Mechanical processes. Washing, picking, breaking up by hand, rock-breakers, crushers, stamps, &c.

(2.) Processes depending upon physical properties: motion in water, motion in air, liquefaction and distillation, magnetic attraction, surface adhesion.

(3.) Processes depending upon chemical properties.
Examples of the methods of preparing ores and stones for the market. Sampling.

STAGE 3.

Candidates in this stage should show decided knowledge of details in their answers, and should be able to give proper sketches with dimensions when necessary in support of their written descriptions. They should be able to discuss the methods of occurrence and working of minerals in some district (of their own knowledge), and also be generally familiar with those of other districts from study. The constructive details of the machinery and engineering works of mines should also be studied in addition to the general principles. Exactness will be expected in all that relates to numbers, dimensions, and weights, and as neat and accurate drawing as the time will permit.

MINING.—BRANCH A.

(Coal, stratified ironstone, fireclay and shale.)

I. Occurrence.

The earth's crust. Stratified and unstratified rocks. Lamination or bedding. Thinning out. Principal varieties of stratified rocks. Dip and strike. Bends. Folds. Contortions. Jointing. Cleat. Unconformability. Geological epochs. Faults of various kinds. Measurement of their throw. Rules for searching for a seam beyond a fault or dislocation.
Minerals worked under the Coal Mines Regulation Act, viz., coal, stratified ironstone, shale and fireclay. Various kinds of coal, geological formations in which workable seams of coal occur. Rocks forming the roof and floor of coal seams, and their importance. Fireclay. Carboniferous period of the British Isles. Oolitic and Tertiary coal in the British Isles. Coal-bearing rocks of the principal British Colonies and foreign countries.
Cannel coal. Oil shale.
Stratified ironstone of the Coal Measures. Black band ironstone.
Stratified ironstone of the Secondary rocks.

II. Prospecting.

Surface indications of coal, stratified ironstone, shale and fireclay. Use of geological evidence and fossils in the search. Geological maps. Extension of the Coal Measures under the Secondary rocks of this country.

III. Boring.

Boring by various methods. Percussive boring by rods and by rope. Rotatory boring with diamond and steel crowns. Tubing boreholes. Accidents to tools. Cores; methods of cutting them and extracting them. Methods of ascertaining the true dip and strike.

SECTION I.

Introductory Subjects, Refractory Materials and Fuel.

Influence of foreign elements on the physical properties of metals.

The principles on which the soldering of metals depends. The action of fluxes in soldering.

Selection of fluxes for ordinary smelting operations. Constitution and fusibility of silicates. Economic applications of slags.

Classification of refractory materials. Properties, approximate composition, and uses of each. Methods of testing them.

Calorific power and calorific intensity of fuel. Evaporative power of coal.

Composition and general characters of the various kinds of fuel required in metallurgical operations. Theory of charcoal burning.

Construction of and mode of working the chief types of modern coke ovens. Utilization of the by-products. Semet-Solvay and Otto-Hoffmann coke ovens.

Gaseous fuels—Natural. Artificially obtained. Siemens' and Wilson's gas producers. Water gas producers. Modes of working these producers.

Principles of the chief forms of pyrometer.

SECTION II.

Iron and Steel.

Iron.—Modes of existence of carbon in iron, grey, white, and mottled cast-iron. Influence of carbon, phosphorus, sulphur, and silicon on iron. Blast-furnace smelting.—Cowper's and Whitwell's hot blast stoves. Selection of fluxes. Character and composition of the fuels required. Character and composition of the slags. Utilization of slags. Composition of the furnace gases. Conditions under which phosphorus, sulphur, silicon, and manganese are reduced in the blast furnace. Grading of pig-iron. Characters, uses, and approximate composition of the different numbers.

Production of wrought iron from cast iron.—In the Swedish Lancashire hearth. Furnace. Characters and approximate composition of the products. Theory of the puddling or "pig-boiling" process. Elimination of impurities in the process. Nature and approximate composition of the products. Utilization of tap-cinder.

Puddling and reheating furnaces with gas as fuel.

Steel.—Modes of effecting the carburization of iron. Effects of different amounts of carbon on the physical properties of steel. Hardening and tempering. Nature of the iron required for the cementation process. Theories of the process.

Materials used in the production of crucible steel. Melting furnaces with gas as fuel.

Approximate composition of the metal required, respectively, for the acid Bessemer, the basic Bessemer, the acid open-hearth and the basic open-hearth processes. Theories of the processes. The utilization of basic slag. Composition of spiegeleisen, and ferro-manganese, and their uses in steel manufactures.

Classification of steel. General characters of the chief kinds of steel.

SECTION III.

Gold, Silver, Lead, Mercury, and Platinum.

Gold.—Influence of various impurities on the physical properties of gold.

General arrangement of a stamp mill for the extraction of gold from ores. Construction of the stamp battery. Amalgamated plates. Mercury traps. The Frue vanner and its uses.

Amalgamation of gold ores in mills.—The Huntingdon mill.

Amalgamation of gold ores in pans. Typical pans and settlers.

VII. Haulage or Conveyance along Level or Inclined Roads.

Mine waggons ("tubs" or "corves"): Dimensions and modes of construction. Rails. Sleepers. Points. Turntables. Calculations as to gradient, resistances and power required. Animal power: Men; horses, mules, ponies, stables, feeding. Mechanical power, various systems of mechanical rope and chain haulage.

Electric railways: Compressed air locomotives.

Self-acting inclined planes for various degrees of inclination. Inclined planes with winding engine ("Engine planes").

Signalling.

Aërial ropeways.

VIII. Winding.

Machinery and appliances required:—Engines, Drums, Ropes and chains of various kinds. Breaking strains and working loads of ropes and chains. Testing wire ropes. Causes of deterioration of ropes and remedies. Greasing. Examination of ropes. Attachments ("cappin[gs]"). Pithead frame. Pulleys. Sinking buckets ("bowk" or "hoppet"). Ca[ges]. Temporary guides for sinking shafts. Permanent guides or conduc[tors]. Keps of various kinds. Onsetting. Landing or Banking. Indica[tors]. Signals. Speed-indicators. Speed-checking appliances. Detaching ho[oks].

Methods of equalizing the load. Koepe and other systems.

IX.—Drainage.

Sources of water met with in mines. Prevention of influx of sur[face] water. Dams of timber, brick and concrete. Drainage tunnels. Siph[ons]. Winding water by buckets or tanks, and modes of filling and dischar[ging] them.

Pumps. Engines above and below ground. Steam pipe carried d[own] the shaft. Transmission of power by rods, water, compressed air [and] electricity. Lifting pumps, force pumps, valves, columns, counter-balan[ces], and safety-catches for rods. Ordinary electric pumps, quick-runn[ing] electric pumps.

Centrifugal pumps; pulsometer; special pumps for sinking purpose[s].

Corrosive water. Duty of pumping engines.

Co-operative drainage.

X. Ventilation.

Composition of air. Causes of the pollution of the air of mines; [(a)] Natural gases finding their way into mines, their composition and proper[ties]. (*b*) Artificial causes of the pollution of the air of mines. Modes of de[tec]tion of the gases by various methods, and determination of their amo[unt] in mine air.

Natural ventilation, its disadvantages and insufficiency.

Artificial ventilation: Furnace; mechanical ventilators of various ki[nds]. Calculations as to quantity, pressure and power. Distribution of the [air] through the workings. Friction of air currents. Equivalent ori[fice]. "Splitting" of air. Thermometer and barometer. Methods of measur[ing] and recording the volume of air passing through the workings. A[ne]mometers. Water gauges. Quantity of air required.

XI. Lighting.

Candles. Lamps. Various illuminating materials employed. Saf[ety] lamps. Principle of the safety lamp. Davy lamp. Clanny, Muese[ler], Marsaut, and other safety lamps.

Cleaning, filling, lighting, locking, re-lighting and testing safety lamp[s].

Stationary electric lamps for the surface and for pit-bottoms. Elec[tric] lamps for sinking pits. Portable electric lamps for working places.

Acetylene lamps.

Elimination of impurities in the refining process. Approximate composition and characters of the products.

The casting of copper.

Composition, physical properties, uses, and mode of manufacture of alloys in which copper is an essential constituent.

ZINC OR SPELTER.—Preliminary preparation of zinc ores—calamine and zinc blende—by calcination. Furnaces employed. Objects of calcination.

Belgian-Silesian furnace for zinc extraction. Mode of working. Retorts and condensers used.

The manufacture of sheet zinc.

TIN.—Preparation of ores for smelting. Reverberatory, and revolving cylindrical calciners. Objects of calcination. Treatment of slags in the Cornish process.

"Hard head."

NICKEL.—Ores of nickel. Characters and chemical composition.

Dry methods of extraction from Canadian sulphide ores. Roasting, melting, concentration of matte. Furnaces and appliances used. Nature of the products. Production of the nickel as a copper-nickel alloy.

Production as metallic nickel.

Chief applications of nickel.

Alloys of nickel.—Composition and physical characters of the most important alloys. Mode of preparation.

COBALT.—Ores of cobalt.

Smalts; mode of preparation. Apparatus used. Nature and approximate composition of the products.

ALUMINIUM.—General principles on which the chief processes for the extraction of aluminium are based.

The physical properties and the most important uses of aluminium.

Alloys containing aluminium.

ANTIMONY.—Ores of antimony.—Characters and chemical composition.

Liquation of stibnite. Furnace and appliances used. Nature of the products.

STAGE 3.

The examinations in Stage 3 and in Honours cannot both be taken in one year.

For a pass at this Stage, candidates will be required to answer questions in three Sections, of which one must be Section I, relating to Refractory Materials and Fuel. More precise and extended knowledge of the preceding subjects will be required than in Stage 2, and in addition the examination will include the subjects indicated below.

The candidate will be expected to recognise and describe ores and metallurgical materials and products of less frequent occurrence than those introduced in Stage 2; only such specimens, however, as are actually met with in metallurgical practice will be placed before him.

He will also be examined in the methods of obtaining samples of metals and materials, and of preparing them for assay, chemical examination, or mechanical testing.

SECTION I.

INTRODUCTORY SUBJECTS, REFRACTORY MATERIALS AND FUEL.

The molecular structure of metals. Segregation.

Allotropism. Occlusion of gases by metals. Properties common to fluids and to solid metals. The diffusion of metals. The constitution of alloys. The micrographic examination of metals. The electric conductivity of metals and alloys. Application of thermo-chemistry to the explanation of the chief reactions in metallurgical processes.

Only a general knowledge of the above subjects will be required.

Details of furnace building, lining, and fettling.

Chimney stacks.
The electric furnace.
Blowing engines and machines.
Mond's gas producer. Comparison and determination of the efficiency of the various kinds of gaseous fuel. Liquid fuel.
Principles of pyritic smelting.
Thermo-electric pyrometer. Electrical resistance and other pyrometers. Applications of these pyrometers.

SECTION II.

Iron and Steel.

Iron.—Preparation of pure iron. Effects of foreign elements—phosphorus, sulphur, silicon, manganese, nickel, chromium, tungsten, aluminium—on the physical properties of iron and steel.
Assaying of iron ores and metallurgical products.
Magnetic concentration of iron ores.
Blast furnace smelting.—Calculation of the charges. Ford and Moncur hot blast stoves. Measurement of the temperature of the blast. Theory of the hot blast. Blowing engines. Collection of by-products from the furnace gases.
Conditions affecting the output and quality of the iron produced. Mechanical arrangements for moulding and handling pig iron.
Desulphurisation of cast iron.
Composition, properties, and mode of manufacture of spiegeleisen, silico-spiegel, ferro-manganese, and ferro-silicon. Nature of the charges and fluxes, and conditions of working the blast furnaces necessary for the production of each.
American blast furnace practice. Swedish blast furnace practice.
Foundry cupola furnace. Mixtures of iron for foundry castings. Use of pig iron containing silicon, and of pig iron containing phosphorus. Chill castings.
Malleable castings.
Old South Wales process for producing wrought iron from cast iron, Furnaces and products.
Mechanical puddling furnaces.
Characters and composition of the various kinds of iron in commerce.
Methods of preparing tinned iron or tin plate and galvanised iron. Apparatus used.
Preservation of iron from rust (Barff's, Bower's, and Russian methods).
Chief varieties and sections of merchant iron.

Steel.—Modes of existence of carbon in steel.
Theories of hardening, tempering, and annealing.
Crucible steel melting.—Precautions necessary to obtain sound ingots.
Mixers used in the Bessemer process. Soaking pits.
The manufacture of rails.
Open hearth steel castings. Means of preventing unsoundness in these castings.
Composition, physical properties, and uses of the various kinds of steel.
Special steels.—Manganese steel. Nickel steel. Chromium steel. Tungsten steel.
Ship plates. Boiler plates. Nickel steel armour plates. Harveyized plates.

SECTION III.

Gold, Silver, Lead, Mercury, and Platinum.

Gold.—Preparation of pure gold.
Various metalliferous minerals containing gold. Assaying of ores and alloys of gold by dry and wet methods.
Ore crushers and stone breakers. Special forms of stamps, amalgamated plates, and n [illegible] of foreign metals and other substances on the am

mbination of steel and timber or steel and masonry.
el and iron supports for working places, with or without the use of
er.

SPECIAL SUPPORTING PROCESSES FOR LOOSE, WATERY, OR RUNNING
TA :—
(*a*) "Spilling," "piling," or "forepoling."
(*b*) Coffering.
(*c*) Sinking linings.
(*d*) Tubbing.
(*e*) Sinking by aid of compressed air.
(*f*) Poetsch or freezing process.
(*g*) Various boring processes with special linings.

VI. METHODS OF WORKING.

ssification and description of methods of working: (1) Subaërial
en workings or quarries; (2) subaqueous workings, dredging, etc.;
ells and bore-holes; (4) combination of open and underground
ings; (5) underground workings.
ssification and description of methods of working underground.
(*a*) by permanent pillars; (*b*) by allowing the roof to fall in; (*c*) by
g up the excavations. Examples.

II. HAULAGE, OR CONVEYANCE ALONG LEVEL OR INCLINED ROADS.

ne waggons; dimensions and mode of construction. Rails. Sleepers.
ts. Turntables. Calculations as to gradient, resistances, and power
red. Animal power: Men; horses, mules, ponies, stables, feeding.
anical power: Various systems of mechanical rope and chain haulage.
ctric railways. Compressed air locomotives. Self-acting inclined
s for various degrees of inclination. Inclined planes with winding
es ("Engine planes").
nalling.
rial ropeways.

VIII. WINDING.

chinery and appliances required:—Engines. Drums. Ropes and
s of various kinds. Breaking strains and working loads of ropes and
s. Testing wire ropes. Causes of deterioration of ropes, and remedies.
sing. Examination of ropes. Attachment ("capping"). Pithead
e. Pulleys. Sinking buckets ("bowk" or "hoppet"). Cages.
porary guides for sinking shafts. Permanent guides or conductors.
s of various kinds. Onsetting. Landing or banking. Indicators.
als. Speed indicators. Speed-checking appliances. Detaching hooks.
thods of equalising the load. Koepe and other systems.

IX. DRAINAGE.

urces of water met with in mines. Prevention of influx of surface
r. Dams of timber, brick, and concrete. Drainage tunnels. Siphons.
ling water by buckets or tanks, and modes of filling and discharging
t.
mps. Engines above and below ground. Steam pipes carried down
shaft. Transmission of power by rods, water, compressed air and
ricity. Lifting pumps, force pumps, valves, columns, counter-balances
safety-catches for rods. Ordinary electric pumps, quick-running
ric pumps.
ntrifugal pumps; pulsometer; special pumps for sinking purposes.
rrosive water. Duty of pumping engines.
-operative drainage.

SECTION IV.

Copper, Zinc, Tin, Nickel, Cobalt, Aluminium, Antimony, Arsenic and Bismuth.

Copper.—Influence of foreign matters on the electric conductivity of copper, and on its properties when used in the manufacture of alloys.

Assaying of copper ores and furnace products by dry and wet methods.

Modern smelting and roasting reverberatory furnaces. Modes of working and products.

Elimination of foreign metals in smelting impure ores.

Elimination of foreign metals in the "best-selected" process.

Kernel roasting. Theory of the process.

Comparison of the chief forms of water-jacketed and brick shaft furnaces for copper smelting. Calculation of blast furnace charges. Essential characters of a good slag in smelting for coarse metal in blast furnaces.

Pyritic smelting.—Typical furnace. Conditions necessary for the success of the process.

Combined shaft furnace and reverberatory furnace methods practised in modern works.

Special forms of converters for Bessemerizing copper mattes.

Smelting processes for copper schist at Mansfeld.

The electrolytic refining of copper.

Recovery of the precious metals in the electrolytic refining of copper.

Varieties of commercial copper. Their composition and uses.

The use of phosphorus, silicon, aluminium, manganese, and iron in the preparation of copper alloys.

Zinc.—Methods of assaying zinc ores and furnace products.

Hasenclever muffle furnace for calcining zinc blende.

Belgian-Silesian furnace for the extraction of zinc, with gas as fuel. Manufacture of Belgian retorts. Improved forms of condensers. Zinc fume. Causes of loss in zinc extraction. Difficulties met with in the application of blast furnaces to the extraction of zinc as metal.

Methods of refining crude zinc.

Electro-deposition of zinc.

Composition of commercial spelter. Impurities and their effects.

Alloys of zinc.

Tin.—Minerals associated with tin ores and their effects on the smelting process, and the refining of tin.

Assaying of tin ores.

Calcination of impure ores. Utilization of the products. Separation of tungsten. Modern method of smelting tin ore in the Malay peninsula. Smelting furnace. Refining furnace and appliances. Products and their treatment.

Foreign metals occurring in tin.

Commercial varieties of tin.

Nickel.—Various metalliferous minerals containing nickel. Methods of assaying nickel ores and metallurgical products.

Methods of extracting nickel from silicate ores. Furnaces used. Composition and nature of the products. Extraction from arsenical ores.

Wet method of extraction from concentrated mattes, or speise.

Mond's carbonyl process. [illegible]-plating.

Composition of the co[illegible] Malleable nickel.

Cobalt.—Natu[illegible]roducts from which cobalt is generally

Hall's process for the preparation of aluminium. Heroult's process. Appliances used in these processes. Composition and nature of the products.

Composition and physical properties of the alloys in the preparation of which aluminium is used. Uses of aluminium as a reducing agent. Other applications in metallurgical processes. Impurities in commercial aluminium.

ANTIMONY.—Assaying of ores of antimony.

English process for the extraction of the metal. Furnace and appliances used. Composition of the products of the different stages of the process. Refining antimony. Characters of the refined metal.

The "roast and reduction" process. Furnaces used. Nature of the products obtained.

Impurities in commercial antimony. Alloys containing antimony. Composition and physical properties.

ARSENIC.—Ores of arsenic. Minerals and metallurgical products containing arsenic.

Methods of estimating arsenic.

Processes and apparatus used in the manufacture and purification of white" arsenic.

Mode of preparing metallic arsenic. Appliances used. Uses of the metal.

BISMUTH.—Ores of bismuth. Other minerals, and metallurgical products containing bismuth.

Methods of estimating bismuth.

Processes and appliances used for the extraction of bismuth from ores containing the metal as "native" bismuth. From ores containing the metal as sulphide.

Wet method of extraction from bismuthiferous litharge and hearths.

Purification of bismuth. Separation of arsenic and of antimony.

Impurities in the commercial metal.

Alloys of bismuth.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Part I. in Honours) of either Theoretical Metallurgy or Practical Metallurgy.

The candidate will be examined in only two Sections of the Syllabus, one of which must be Section I., the other to be selected by himself.

A very thorough and exact knowledge of the subjects of the preceding stages—in Section I. and in the section which the candidate may select—will be required in this examination, as well as a satisfactory acquaintance with the subjects indicated below.

He will be expected to show familiarity with the designs of works, metallurgical plant and appliances; with the working details of processes, and with the results of recent metallurgical researches; and questions will be asked at the discretion of the examiner, who will have regard to the present state of metallurgical practice in this and other countries.

1. The selection of sites for works.
2. The preparation of working drawings for the building of furnaces and chimney stacks, and of plans and sections of metallurgical works.
3. Methods of dealing with irregularities and accidents in the working of furnaces.
4. The causes and prevention of undue losses in metallurgical processes.
5. The composition and physical properties of the metals and their alloys in the various forms met with in manufacturing industries, and chemical and mechanical tests usually applied to determine their fitness for special purposes, including those contained in makers' specifications.

6. The extraction and refining of metals by electrolytic processes.

In this examination two papers will be set, of which Paper I. will be set at the Evening Science examinations. Those candidates who answer the questions in Paper I. in a sufficiently satisfactory way will be required to undergo a further examination at South Kensington, which will consist of two parts, viz., a written examination (Paper II.) and an examination in practical work (for particulars *see* page 121). No candidate can be classed in Honours who is not successful in both the written and practical parts of the examination.

SUBJECT XIX*p*.—METALLURGY, PRACTICAL.

STAGE 1.

The examination will test the candidate's practical knowledge of:—

(*a*.) The principles on which "calcination," "roasting," and "reduction are based.
(*b*.) The testing of refractory or fire-resisting materials.
(*c*.) The preparation of common alloys, such as pewter, brass, and bronze.
(*d*.) Simple experimental determinations of the effects of foreign substances on the mechanical properties of metals.
(*e*.) The subjects indicated below.

Four hours will be allowed for the examination. The use of books on metallurgy will be permitted.

FUEL. Evidence as to the value of a coal afforded by distillation in a closed vessel.

REFRACTORY MATERIALS.—Testing of fire-clay and other refractory materials, fire-bricks and crucibles, with a view to ascertain, 1st, their capability of sustaining a high temperature; and 2nd, their power of resisting the corrosive action of fused metallic oxides.

METHODS ADOPTED IN THE EXTRACTION OF METALS FROM THEIR ORES.

ROASTING.—Conversion of metallic sulphides into oxides and sulphates by roasting in the muffle furnace, especially copper, lead, silver, and zinc sulphides.

REDUCTION.—The reduction of iron oxide will be best taught in this stage by the heating of hæmatite in small clay crucibles or in crucibles lined with charcoal, suitable fluxes and reducing agents being added. The student must be taught to recognise, from the fracture of the button, the variety of iron produced.

Reduction of copper oxides and of lead oxides by carbon.

Reduction of lead sulphide by the mutual action of the sulphide and oxide.

Reduction of copper from copper sulphide by the action of the sulphide on copper oxide. In these cases the mixture is so adjusted that the relation between the sulphur and oxygen shall be the same as in sulphur di-oxide.

Reduction of lead sulphide by metallic iron.

CEMENTATION (OXIDIZING AND CARBURIZING).—The leading effects that attend, (1) the prolonged heating of thin pieces of cast iron in hæmatites and (2) the prolonged heating of wrought iron in charcoal.

SCORIFICATION AND CUPELLATION.—The general features of the enrichment of argentiferous lead by scorification in a muffle with subsequent separation of the silver by cupellation on a bone ash cupel.

Purification of Metals.

Dry Methods.—Refining copper by oxidizing and "poling" commercial per melted in a crucible. The student should make himself familiar h the characteristics of the ingot of metal in the three states known as:— dry copper"; 2, "tough copper"; 3, "overpoled."

Alloys.

: will be well, in the first instance, to cause the student to prepare alloys hich the chemical physical, or mechanical properties differ widely from se of their constituent metals, and to direct them to ascertain, so far as facilities of the laboratory will permit, that the alloys so prepared corre- nd with the descriptions usually given of them. Such alloys would be f the copper-zinc series, one or more kinds of brass; (2) of the copper- alloys, speculum metal and gun metal; (3) of the tin-lead series (with or hout other metals, fusible metal). They should also prepare the "regulus Venus" (copper and antimony in equal parts by weight), and they should shown that an alloy of equal parts by weight of lead and zinc will sepa- s into two nearly distinct layers when slowly cooled from fusion, and that with a small percentage of arsenic resembles zinc

STAGE 2.

The candidate will be required to conduct at least two of the operations umerated below, or in the syllabus for Stage 2, on materials which will supplied to him.
Five hours will be allowed for the examination. The use of books on tallurgy will be permitted.

Fuel.—Determination of the amount of ash and sulphur in fuel.
Determination of the calorific power of coal with the aid of Thompson's orimeter.

Refractory or Fire-resisting Materials.—The student should pre- e for himself small clay crucibles from a material consisting of two parts, measure, of unburnt to one part of burnt Stourbridge clay, some of these cibles being lined with a mixture of charcoal powder and treacle. Cupels bone ash must also be prepared.

Reagents and Fluxes.—The action and uses of the common reagents l fluxes employed in assaying. Experiments demonstrating their eral properties.

Slags.—Experiments on their formation.

Roasting.—Experimental solution of problems involved in roasting mplex mixtures of metallic sulphides.
Estimation of the amount of compounds soluble in water produced by sting certain mixtures of metallic sulphides.

Reduction, Smelting, &c.—Reduction of lead sulphide by the reaction sulphide and sulphate.
Reduction of antimony sulphide by iron.
Reduction of copper silicates by fusion with iron oxides or lime, and rcoal.
The fusion of copper silicates with iron sulphides.
The production of coarse metal, white metal, and metallic copper from per pyrites.
The production of steel may be studied by fusing wrought and cast n together in suitable proportions.

Amalgamation.—Action of metallic mercury when triturated with allic silver, artificially prepared silver sulphide, and silver chloride; aration of the amalgam formed in each case; its concentration by eezing in leather, and subsequent distillation.

LIQUATION.—Separation of native antimony sulphide from its gangue.
Separation of argentiferous lead from an alloy of 50 per cent. lead and 50 per cent. copper, by heating a disc of the alloy somewhat above the melting point of lead, so that the more fusible metal can flow away, leaving an impure sponge of copper behind.

CUPELLATION AND SCORIFICATION.—Determination of the amounts of lead required to effect the removal by cupellation of small and varying amounts of copper alloyed with silver.
The behaviour of tin, antimony and zinc, and of copper-zinc and copper-nickel alloys when cupelled with lead.
The behaviour of tin, antimony and zinc containing silver, and of copper-zinc and copper-nickel alloys containing silver, when scorified with lead.
The extraction of silver from ores by fusion with lead oxide, charcoal and suitable fluxes, and subsequent cupellation of the argentiferous lead obtained.

CHLORINATION.—Formation of gold chloride by the action of chlorine gas on finely divided gold. Solution of the chloride in water, and the precipitation of the gold by ferrous sulphate. Preparation of silver chloride. Solution of the silver chloride in brine, and separation of the metal from solution by metallic copper. Preparation of silver sulphate. Solution of the silver sulphate. Separation of the silver from the solution by the action of metallic copper.
Treatment of copper pyrites by roasting with common salt, and subsequent extraction of the soluble copper chloride by water.
Treatment of pyrites mixed with silver sulphide by roasting with common salt, and estimation of the amount of silver that has been converted into chloride as shown by the solvent action of sodium hyposulphite.
Treatment of auriferous iron pyrites by roasting with salt; conversion of the compound so formed into finely divided gold by an elevation of temperature, and subsequent conversion of the gold into chloride soluble in water by the action of chlorine gas. Recovery of the gold from solution by precipitation with ferrous sulphate.

PURIFICATION OF METALS.

WET METHODS.—Separation of copper alloyed with silver and gold by "parting" with sulphuric acid, recovery of the silver from solution by metallic copper, and of the copper from the copper sulphate so formed by metallic iron. [This will be useful to the student as showing the replacement of a metal in solution by a cheaper one.]
Separation of gold from silver by "parting" with nitric acid; recovery of the silver by precipitation as chloride, and its subsequent reduction to the metallic state by zinc or iron.

STAGE 3.

One day of eight hours will be allowed for the examination.
The use of note-books and works of reference will be permitted.
The experimental work will include the subjects of the previous stage as well as those indicated below.
The candidate may be required to take up and complete an analysis already in progress, and to
The production of copper "bottoms"
precipitation of gold from
chief

timation of silica, lime, and iron in slags, and of silica in acid
materials.
imation of lime and magnesia in basic refractory materials.
imation of iron, gold, silver, copper, zinc, nickel, and tin in the
lloys of these metals.
paration of chemically pure gold and silver.

HONOURS.

amination forms part of the further examination in Honours,
urgy (*see* page 118), and can only be taken by candidates who
instructed to attend.
mination will occupy two days.
ates will be permitted to use note-books and works of reference.
erimental and analytical work will include the subjects of the
Stages, in addition to those enumerated below.
rification of nickel by wet methods.
imation of impurities in commercial metals and alloys.
es of ores, fuel, fluxes, refractory materials, and slags and other
ical products.
of gold and silver coins and bullion by the methods practised in
Assays of base gold and silver bullion.
termination of the electric conductivity of copper.
ndidate will be required to show a practical acquaintance with
tical processes and practical tests in use in metallurgical works.
this examination the examiner may, at his discretion, put
to the candidate on the work set in the paper.
s on the subject of an experimental metallurgical investigation
candidate has conducted may be sent in, and will be taken into
tion in the award of marks. The authenticity of the thesis must
rly attested.
work allotted to the candidates due regard will be paid to the
of the syllabus in which they have been examined in the written
ion. (*See* Metallurgy, Theoretical. Honours.)

Laboratory for Practical Metallurgy.

st cases comparatively small additions to the Chemical Labora-
anged and furnished in accordance with the prescribed regulations
65), will enable Practical Metallurgy to be taught.
cessary that one or more wind furnaces should be provided, and
naces should be in connexion with a flue at least 30 feet high.
aces may be placed in a basement below the laboratory, but there
ction, if space permits, to one being in the laboratory.
nust also be a muffle furnace capable of heating to bright redness
t least 8 inches long, 4 inches wide, and 3 inches high ; when there
undant supply of gas, gas muffle furnaces may be adopted with
e.
re than three candidates will be allowed to use the same muffle
t any examination in Practical Metallurgy.
uffle furnace may be in the laboratory, as it is also useful in
g various chemical operations.
tudent should be provided with the tools and appliances set forth
, and those named in List II. must be kept in the laboratory for
f the students.
I. gives the reagents, fluxes, &c., that will be required by the
for general use.

List I.

Each student in Stages 2 and 3 and in Honours must be provided with the following articles. In Stage 1 the student need only have the articles that are marked with an asterisk :—

*1 small hammer.
1 small anvil.
1 drill.
*1 steel spatula.
*1 camel hair brush.
*1 hard tooth brush.
2 sheets of glazed paper.
*1 pair of scissors.
1 pair of pliers—half round, taper.
1 pair brass forceps.
*1 triangular file.
*1 wire triangle—covered.
2 glass rods.
1 glass funnel, 3 inches diameter.
4 beakers, Nos. 5, 6, 7, and 8.
1 washing bottle, fitted.
2 conical flasks and small funnels.
2 Bohemian flasks, 24 oz.
1 Berlin evaporating dish, No. 7.
1 do. No. 2, 3½ inches diameter.
*1 porcelain mortar.
*1 porcelain crucible, 1½ inch diameter.
1 packet of filters, 5½ inches diameter, or filtering paper
6 test tubes.
2 feet combustion tubing.
1 lens.
*6 scorifiers, 2½ inches diameter.
12 cupels.
*6 earthen crucibles, each size, 1¾, 2½, and 3 inches diameters.
*1 black lead crucible, 3 inches diameter.
*2 roasting dishes, 3 inches diameter.
*1 duster or cloth.
*1 note book.
½ oz. silver, or old or foreign silver coin.
2 dwts. gold, or old or foreign gold coin.

List II.

The following must be kept for general use :—

3 pairs of furnace tongs.
1 open ingot mould.
1 ingot mould with hemispherical cavities.
1 copper scoop.
1 cupel mould.
1 mould for making small clay crucibles.
2 iron cupel trays.
1 iron mortar.
1 anvil, 4 inches by 4 inches.
1 hammer.
1 pair of metal shears.
1 pair of flatting rolls.
1 bucking plate and iron.

List III.

ıg metals and reagents, which need not be of a high degree of be kept in addition to the ordinary stock of a Chemical

	Red Lead.
	Lead Sulphate.
	Manganese Oxide (black).
	Mercury Sulphide (red).
ınd wire).	Nickel Oxide.
. sheet free from silver).	Tin Oxide.
	Zinc Oxide.
	China Clay.
	Glass, Powdered.
	Lime.
	Salt.
ulphide (black).	Fire-clay.
ide.	Silicious sand.
le (black).	Fluorspar.
hate.	Red Argol.
le.	Borax.
	Dry Sodium Carbonate

SUBJECT XX.—NAVIGATION.

nination in this subject mathematical tables, without any y candidates taking Honours, the "Nautical Almanac" for the nay be used.
questions may be set at the examination.

STAGE 1.

NOTIONS AND DEFINITIONS.—Figure of the earth; diameters ; axis, poles. Definitions of equator, meridians; latitude; latitude; difference of latitude; longitude; difference of xplanation of the relation between longitude and local time. of rhumb line; course; departure; distance.

ASS.—Description; definition of the term "point." Conversion ı of a point into degrees, minutes, and seconds, and conversely.

OF COMPASS.—Definition of the term. Rules for applying (1) in finding true course from compass course; (2) in finding e from true.

OF COMPASS.—Definition of the term. Description of ıding deviation practically.
f correction of courses for variation and deviation.

Definition of the term. Explanation of the method of corse for leeway.

ND LOG-LINE.—Description. Method of dividing the log- l account of the patent log.

—Description of instruments used in sounding.

SAILING.—Proof of formula connecting latitude, distance, and ongitude, with examples.

LING.—Proofs of formulæ connecting departure, difference of nce, and course, with examples.

SAILING.—Method of resolving a traverse. Construction of

ATITUDE SAILING.—Proof of formula used, with examples.

STAGE 2.

MERCATOR'S PROJECTION AND CHART.—Principle of construction, and advantage resulting from use of this projection.
Proofs of rules made use of, with examples.

DEVIATION OF COMPASS.—Fuller description of methods for ascertaining amount of deviation. Distinction between semi-circular and quadrantal deviation, with the causes of each.

GREAT CIRCLE SAILING.—Having given the latitudes and longitudes of two places, to find the distance between them on a great circle. To find the latitude and longitude of the vertex. To find a succession of points on a great circle, and the course to be steered at each point. Composite sailing.

THE LOG-LINE.—To find the error in distance run resulting from a given error in glass or line. Examples.

DAY'S WORK. To explain the methods of taking a departure. To correct the courses entered in the log-book, and work out the reckoning for twenty-four hours by means of the traverse table.

TRAVERSE TABLE.—Use of this table in the solution of right angled Plane Triangles generally.
Windward Sailing, Current Sailing, and other practical problems involving the solution of Plane Triangles.

N.B.—In Stage 3 Navigation and Nautical Astronomy are regarded as a single subject. For details see Navigation and Spherical and Nautical Astronomy.

SUBJECT XXI.—SPHERICAL AND NAUTICAL ASTRONOMY.

At the examination in this subject mathematical tables, without any treatise, and the "Nautical Almanac" for the current year may be used.
For the examination in this subject, the paper in Stage 1 and in Stage 2 will be divided into three sections—the first dealing with both Spherical and Nautical Astronomy, the second with Spherical, and the third with Nautical Astronomy. The answering of a certain number of questions from the first section may be made compulsory. The questions in the second section will be alternative to those in the third.

(a)—SPHERICAL ASTRONOMY.

Spherical Astronomy treats of the relative positions and apparent motions of the heavenly bodies. The movements are those which we see, and it is usual and very convenient to speak of them as real. Thus we speak of the sun's diurnal motion, though it is a matter of common knowledge that that motion is only apparent, and is actually due, chiefly to the rotation of the earth, and partly to the earth's motion in its orbit. The fundamental conception of the apparent motion of the heavens is that the heavens are a sphere at the centre of which the observer stands, and which turns with a uniform motion about a fixed diameter. The stars appear as bright points fixed on the inner surface of this sphere and turning with it. They all partake in the motion of the great sphere, and are called fixed stars because they are fixed relatively to each other on the sphere. One of the greatest preliminary difficulties of this subject is the acquisition of a clear understanding of the great sphere and its diurnal motion. One of the most effective aids to obtaining this understanding is to practise the representation of the lines and circles of the great sphere by carefully drawn diagrams of them by means of the stereographic projection. This method of projection is by no means difficult, as all circles on the sphere are circles (or straight lines) in the projected diagram, so that the construction can be made with a ruler, a pair of compasses, and a protractor. It is with this view that Stage 1 contains a number of questions relating to the stereo-

hic projection; but, incidentally, two other advantages are gained:—
he diagrams thus obtained are in most cases very superior, in point
istinctness, to rough freehand perspective drawings which are often
and put plainly before the student the lines and angles which
the subject of calculation in the subsequent stages. (*b*) With
rate care in the drawing many problems can be approximately solved
t from the diagram—*e.g.*, assuming that angles can be protracted to
a degree, it is easy to find by construction the time of the rising or
g of a known star to within two or three minutes of time and the
of the horizon at which the rising or setting takes place to within
legree of angle. These are very rough results compared with what
l be obtained by calculation, but they are useful for some purposes,
ery instructive to a student in the earlier stages of his progress. It
further be remarked that when points are spoken of as fixed, and
ities as having a definite amount, it will always (or nearly always)
n that the determinations are approximations which, for present
ses, are treated as exact, but which will need correction as the
t is gradually developed—*e.g.*, the statement that the great sphere
uniformly about a fixed diameter is sufficient, and indeed necessary,
t; but the student will find that it requires and will obtain modifica-
s he goes on with the subject.

students should bring into the examination the necessary drawing
ments, viz., a scale of equal parts, a protractor, and a pair of
asses. There are other scales, such as a scale of chords, which may be
l, but are not essential.

student should also have a copy of the "Nautical Almanac." He
ave to use several of the tables in the course of his studies, and some
very beginning. It is well known that the "explanations" at the
f the Almanac are of great value. The student will find it necessary,
nost instructive, to make himself gradually acquainted with these
nations.

STAGE 1.

Definitions.

1) The student should make himself acquainted, by actual observation, with some of the principal constellations and most conspicuous stars, *e.g.*, The Great Bear, Orion, The Twins, The Lion, The Virgin, The Eagle, &c.; the Pole Star, Aldebaran, Capella, Sirius, Regulus, Spica, Arcturus, and α Lyræ (Vega), and α Aquilæ (Altair), &c.

2) Definitions of the lines and points fixed relatively to the spectator, *e.g.*, Horizon, Zenith, Nadir, Poles, Vertical circles, Meridian, Prime Vertical, &c.

3) Definitions of lines and points fixed on the great sphere, *e.g.* Equinoctial or Celestial Equator, Declination circles, Right Ascension, Declination, &c.

4) The proper motion of the sun. N.B.—This is a very important point, and the learner will be greatly helped in understanding it if he will carefully notice on a few consecutive nights the position of the moon among the stars. He cannot fail to see that while the moon shares in the motion of the great sphere from east to west, she is all the while moving on the sphere from west to east, so that she works once round the sphere in about 27 or 28 days. What the moon does visibly in the course of a month is very nearly the same as what the sun does in the course of a year, though not so obviously. However, by observing the stars that set shortly after the sun the proper motion of the sun becomes plain.

(5) The constellations through which the sun is carried in the course of a year by its proper motion. The Ecliptic, the obliquity of the Ecliptic, the first point of Aries, the first point of Libra, the solstices, the celestial latitude and longitude of a point on the great sphere.

(6) The latitude and longitude of a station. The latitude is the arc of the meridian between the elevated pole and the horizon. The longitude of a station is the angle at the pole between the meridian of the station and the meridian of Greenwich (or other standard station). This latitude and longitude must be kept quite distinct from the celestial latitude and longitude in No. 5.

(*b*) Of time.

(1) The sidereal day, and its subdivisions. The sidereal time of an instant, which is shown by the sidereal clock.

(2) The apparent day; not an unit of time. The apparent time of an instant, which is shown by a sundial.

(3) The mean sun. The mean solar day and its subdivisions. The mean time of an instant, which is shown by a common clock. The civil and astronomical reckoning of the mean time of an instant.

(4) Given the longitude of a station, and the Greenwich time of an instant, to find the local time of the instant, and *vice versâ*.

(5) The hour angle of the sun or of a star. The equation of time can be taken from p. I.* of the "Nautical Almanac" for any instant of Greenwich apparent time, and from p. II. for any instant of Greenwich mean time. Given the apparent time of an instant, to find the mean time, and *vice versâ*.

N.B.—The student should observe that for finding the equation of time at any instant of local time, it is only necessary to know the longitude of the station approximately. Thus, an error of 1° (or 4ᵐ) of longitude would never cause an error of as much as a tenth of a second of time in the equation of time.

(6) Given a portion of time expressed in mean solar units, to express it in sidereal units, and *vice versâ*, by means of the Table of Time equivalents given on pp. 586–589 of the "Nautical Almanac," or otherwise.

(7) Given the mean time of an instant, to find the sidereal time of the instant, and *vice versâ*.

(*c*) The graphic representation of the points and circles defined above.

(1) Definition of the stereographic projection of points and circles on a sphere.

(2) The stereographic projection of every circle, great or small, is a circle, or, as a limiting case, a straight line.

(3) The angle between the planes of two great circles equals the angle between their projections at the point of intersection.

(4) The nadir being taken as the projecting point and the horizon as the plane of projection, to draw the horizon, the zenith, the meridian, the prime vertical, and any vertical circle.

(5) Given the altitude of a point on an assigned vertical circle, to construct its projection, and, conversely, given its projection to find its altitude.

* It is hardly necessary to mention that in the "Nautical Almanac" Arabic numerals refer to the page of the volume; Roman numerals to the page of the month. Thus p. V. in June is p. 96 of the volume.

(6) As a particular case of (5), given the latitude of a station to construct the projections of the north and south poles.

(7) To construct a declination circle which makes a given angle with the meridian.

(8) Given the polar distance of a star, to construct the projection of its positions when on the meridian, and hence to construct the diurnal path of a given star.

(9) To construct the projection of the equinoctial, and of the position of the first point of Aries at a given time.

(10) Given the right ascension and declination of a star, to construct the projection of its position at any given time.

(11) To construct the projection of the ecliptic at any time.

N.B.—In making the constructions specified above the student should, in the first instance, suppose that his station is at or near Greenwich. He should next consider how they would be modified in case his station were in the Southern Hemisphere, *e.g.*, in New Zealand, or in case it were nearly under the line, *e.g.*, at Colombo.

(*d*) Some applications of the constructions given in (*c*), such as the time of the rising and setting of a given fixed star, its amplitudes at rising and setting, its zenith distance at culmination, the time and altitude at which it crosses the prime vertical, the duration of twilight at different times of the year.

N.B.—The right ascension and declination of each of the principal known stars are given on pp. 295-305 of the "Nautical Almanac." The right ascension and declination of the sun (*i.e.* of the centre of the sun's disc) are given for every day of the year on pp. I. and II. of each month.

(*e*) The Instruments of an Observatory.

N.B.—The description of the Instruments should be concerned only with the arrangement of the parts, and with the observations that can be made by them. It may be remarked, first, that the subject of instrumental errors is reserved for a more advanced part of the course; secondly, that observations made in the plane of the meridian are capable of very great exactness.

(1) To lay down a north and south line, and to set up a north mark.

(2) The tangent screw and the reading microscope. The vernier.

(3) The astronomical telescope; the positive eyepiece; the field of view; the line of collimation.

(4) The sidereal clock; its rate and error of rate.

(5) The transit instrument; the observation of a transit of a star, of the sun, &c.

(6) The mural circle. The observation of a meridional zenith-distance. The collimating eyepiece.

(7) The transit circle.

(8) The equatorial.

(9) The alt. azimuth instrument.

(*f*) Approximate determination of certain fundamental quantities.

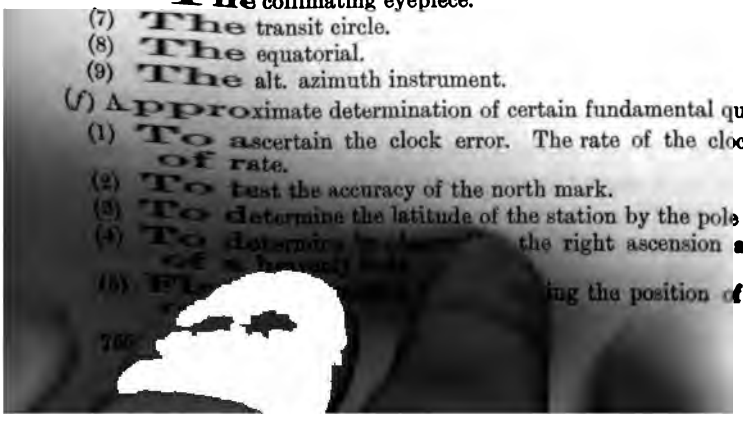
(1) To ascertain the clock error. The rate of the clock and its error of rate.

(2) To test the accuracy of the north mark.

(3) To determine the latitude of the station by the pole star.

(4) To determine [illegible] the right ascension and declination.

(5) [illegible] ing the position of the first point



(*g*) Questions that may be asked in connection with various tables in the "Nautical Almanac," such as the following :—

(1) To find the variations in the sun's proper motion from p. III., and in his distance from p. II.

(2) From p. IV. to find the longitudes of the ascending and descending nodes of the moon, and the variations in their position through the year.

(3) From p. III. to find the variations in the moon's distance through the month.

(4) From the planetary ephemerides (pp. 218–282) to ascertain the period through which the proper motion of a planet (*e.g.*, of Mars) is direct, that through which it is retrograde, and the times at which it is stationary.

(5) Also to represent graphically the apparent path of a planet (*e.g.*, of Mars) with reference to the ecliptic.

(6) In the case of Venus or Mercury to ascertain its position when it is at its greatest elongation.

STAGE 2.

In Stage 2 it will be assumed that the student knows Trigonometry, both Plane and Spherical; a knowledge of the Elements of the Differential Calculus may be useful for dealing with some of the questions that may be asked. The following syllabus only indicates the heads of the subjects comprised in the course, without going into details. Stage 2 presupposes a knowledge of Stage 1, and in the Stage 2 paper questions may be asked which are within the scope of the Stage 1 syllabus.

(*a*) Problems on transformation of co-ordinates. Such as :—

(1) From the hour angle and declination to find (the latitude being given) the altitude and azimuth, and the converse.

(2) From the right ascension and declination to find the (celestial) latitude and longitude, and the converse.

(*b*) Problems arising out of the diurnal motion of the heavens. Such as :—

(1) Time of culmination and zenith distance at culmination of a heavenly body.

(2) Time of rising and setting of a heavenly body.

(3) The greatest elongation of a circumpolar star.

(*c*) Corrections which depend on changes in the position of points and planes of reference :—

(1) The earth's centre being supposed to be fixed, to describe the motion of the earth's axis.

(2) The precession or motion of the first point of Aries.

(3) The periodic change in the obliquity of the ecliptic, *i.e.*, the nutation of the obliquity.

(4) Secular variation of the obliquity of the ecliptic.

(5) Graphic representation of the nutation by an ellipse.

(*d.*) Corrections which depend on the position of the observer.

(1) The form and dimensions of the earth.

(2) The equatorial horizontal parallax, particularly of sun and moon.

(3) The parallax in altitude.

(4) The parallax in right ascension and declination.

(*e*) Corrections which depend on certain properties of light

(1) Refraction of light.

(2) Refraction in altitude, for homogeneous atmosphere.

(3) Modifications rendered necessary by the actual condition of the atmosphere.

(4) Tables of atmospheric refraction.

(5) Refraction in right ascension and declination.

(6) Effect of refraction on the time of rising and setting of stars.

(7) The duration of twilight.

(8) The aberration of light. The constant of annual aberration.

(9) The annual aberration of a star in latitude and longitude. Also in right ascension and declination.

(10) Diurnal aberration.

(*f*) The problem of reducing the mean place to the apparent place of a fixed star, and the converse.

(1) Bessel's day numbers, A, B, C, D, on p. 307 of the "Nautical Almanac."

(*g*) The sun's proper motion.

(1) Determination of the sun's apparent orbit, of its eccentricity, and of the position of its major axis.

(2) Determination of the variation of the sun's angular velocity.

(3) Determination of the motion of the perigee.

(*h*) The moon's motion and her phases.

(1) Her apparent diameter, parallax, distance and actual diameter.

(2) Her approximate orbit, and inclination of the plane of the orbit.

(3) Variations in the form of her orbit, in the position of its line of apses, and in the position and inclination of the plane of the orbit.

(4) The moon's sidereal period; her synodic period or lunar month.

(*b*)—NAUTICAL ASTRONOMY.

N.B.—In Stages 1 and 2 questions may be asked in Spherical Trigonometry, so far as it is required in the solution of problems belonging to these sections.

STAGE 1.

Definitions of all terms made use of.

TIME.—Distinction between civil and astronomical time, and between apparent and mean solar time. Conversion of arc into time, and *vice versâ*. Definition of the term "Greenwich date."

EQUATION OF TIME.—Definition of, with explanation of its use.

NAUTICAL ALMANAC.—Explanation and use, so far as observations of the sun for latitude and longitude are concerned.

THE SEXTANT.—Construction and use, with explanation of the principle of sextant, and of the various adjustments. Explanation and use of artificial horizon.

CHRONOMETER.—Explanation of the use of the chronometer in finding longitude.

CORRECTIONS OF ALTITUDE.—Causes and general description of the corrections, with use of tables. To prove the rules and work examples in the following problems :—

1. Latitude by meridian altitude of the sun.
2. Longitude by sun chronometer.
3. Error and rate of chronometer by a single alt tude of sun.
4. Compass error—
   (*a*.) By sun amplitude.
   (*b*.) By altitude-azimuth.

STAGE 2.

TIME.—Distinction between various kinds of time. Conversion of an interval expressed in sidereal into mean time and *vice versâ*. Time of meridian passage of heavenly bodies.

EQUATION OF TIME.—General account of, and use.

NAUTICAL ALMANAC.—Explanation and use of the various tables for supplying elements of sun, moon, stars, or planets.

CORRECTIONS IN ALTITUDE.—Explanation of the reasons for the various corrections for dip, refraction, parallax, and semi-diameter, with diagrams, but without investigations.

THE SEXTANT.—Proofs of theorems connected with the sextant, artificial horizon, and vernier.

To work and explain the following problems, explaining the processes made use of :—

1. Latitude by meridian altitude of star, planet, or moon.
2. Latitude by altitude of Polaris.
3. Latitude by ex-meridian altitude of sun, moon, star, or planet.
4. Latitude by double altitude of sun, moon, star, or planet, or any combination of these bodies.
5. Longitude by star, planet, or moon chronometer.
6. Error of chronometer by single altitude of star. Rate of chronometer.
7. Error of chronometer by equal altitudes of sun or star.
8. Compass error by Time-azimuth.
9. Sumner's method of finding position. To describe and explain the method of "double chronometer."
10. Tide Tables. Explanation of the term "Establishment of Port," with the use of tables for finding time of high water.

NAVIGATION AND SPHERICAL AND NAUTICAL ASTRONOMY.

STAGE 3.

The examination in Stage 3 will include the contents of the foregoing Syllabuses of Navigation and Spherical and Nautical Astronomy, but the questions will be of a more difficult character. New subjects also will be added, as indicated in the lists which follow.

NAVIGATION AND NAUTICAL ASTRONOMY.

MERCATOR'S CHART.—Practical construction.

MAGNETISM OF SHIPS.—How to exhibit the deviation of compass by Napier's graphic method. How to determine practically the various coefficients, A, B, C, D, E.

OCEAN METEOROLOGY.—Descriptio[illegible]e Winds and other constant winds, and of the principal Monsoo[illegible]

Easy problems in Nautical Sur[illegible]

TIME.—More general problems.

Such knowledge of general astronomy as would suffice to explain the real and apparent motions of the heavenly bodies, and the principal celestial phenomena, such as eclipses, occultations, &c.

Investigation of corrections for dip, refraction, parallax, and augmentation of moon's semi-diameter, with the method of tabulation.

More general explanation of Sumner's method of finding a ship's position, with practical examples.

LUNAR DISTANCES.—To explain the process of finding longitude by lunar distances, and to work examples.

General problems, such as those affecting the times of rising and setting of heavenly bodies, duration of twilight, etc.

SPHERICAL ASTRONOMY.

(*a*) Questions on Stage 2 with extensions.

(*b*) Instrumental Errors, so far as the transit instrument is concerned. Investigation of formulæ for determining the effect of such error on the time of transit.

(*c*) Interpolation, by second differences.

(*d*) Determination of the latitude of a station :—

(1) By circummeridional altitudes.

(2) By an altitude of the pole-star out of the meridian.

(*e*) Determination of the difference between the longitudes of two stations :—

(1) By the chronometer.

(2) By signals, and by the electric telegraph.

(3) By moon-culminating stars.

(*f*) Eclipses of the sun and moon ; conditions under which they occur ; the chief differences between the phenomena of lunar and solar eclipses.

(*g*) On time, supplementary to the article (*b*) on time in the syllabus of Stage 1.

(1) The equation of time ; the elements of which it is made up ; its greatest and least values ; proof that it vanishes four times a year.

(2) The sidereal year, the tropical year, the anomalistic year.

(3) The Julian Calendar, and the Gregorian Reformation.

(4) The Solar Cycle, and the Lunar (or Metonic) Cycle.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3, or in Honours in either Sub. XX. or XXI.

The subject of the Examination in Honours will be partly on the contents of the foregoing Syllabuses, but the questions will be of a more difficult character. New subjects also will come into view, as will appear from the following list.

NAVIGATION AND NAUTICAL ASTRONOMY.

(*a*) Investigation of formula for calculation of Meridional Parts for a given latitude.

(*b*) MAGNETISM OF SHIPS.—Full account of various causes of deviation, with Heeling Error, and method of compensation by magnets, &c.

(*c*) Harder problems in Nautical Surveying.

(*d*) General knowledge of prevailing winds and currents over the earth's surface. Laws governing circular storms.

(*e*) Investigation of Nautical Almanac method of finding latitude by Polaris, and of the equation of equal altitudes.

(*f*) Investigation of errors in latitude, hour angle, and azimuth, resulting from given small inaccuracies in the various data. Deductions as to the most advantageous times for taking particular observations.

(*g*) Full explanation of the various applications of Sumner's method including that of Marcq-Saint-Hilaire.

(*h*) More difficult general problems.

SPHERICAL ASTRONOMY.

(*i*) Questions on Stages 2 and 3, Spherical Astronomy with extensions.

(*j*) Discussion of Instrumental Errors, and of the formulæ for calculating the effects produced by known errors on observations, particularly on observations of transits and zenith distances. In regard to this article it must be remembered that when large and exact instruments are concerned it is found best not to attempt to give the observations their last degree of exactness by mechanical means; but to determine the residual errors of the instrument and to calculate the corrections that have in consequence to be applied to the observation. The subject of Instrumental Errors is one of great interest and considerable extent.

(*k*) Interpolation.

(*l*) On errors of Observation, and the combination of Observations.

(1) The law of frequency of error.

(2) Mean error; error of mean square; probable error.

(3) Determination of the probable error of the arithmetical mean of a number of observation of the same quantity.

(4) Determination of the values of two, three or more quantities whose probable errors are least from a system of equations; and to find the probable errors.

N.B.—Several of the articles in the foregoing Syllabuses admit of considerable extension, particularly:—

(1) Section (*g*) Stage 2, may be extended into a discussion of the planets generally.

(2) Section (*h*), Stage 2, on the moon, may be extended by including the principal inequalities.

(3) Section (*e*), Stage 3, may be extended by including the determination of longitude by occultations, or by the eclipses of Jupiter's Satellites.

(4) Section (*f*), Stage 3, may be extended by a discussion of the circumstances of an eclipse.

SUBJECT XXII.—STEAM.

Compulsory questions may be set in any of the examination papers. The necessary Tables (*see* p. 34) will be supplied, and candidates will be restricted to the use of these Tables, and will not be allowed to bring with them into the examination room any other Mathematical or Logarithm Tables. Slide Rules may be used.

STAGE 1.

In preparing candidates for this examination a teacher will do well to start with a sectional model of a direct acting engine, using also the parts of an actual small engine which students may examine, sketch, and measure

themselves. The names of the various parts and how they work ought to be given. Neglecting the valve motion, let the advantages of ansion and the behaviour of the steam be explained, with the idea of cocks, admitting and releasing steam from the ends of the cylinder. packing of the piston and the stuffing box. The teacher need not fear ive a student a good deal of information about details of quite different nes from the one before him : a student will not be expected to answer cult questions on such matters, and he may not seem to take in such rmation, but he is really getting a sound knowledge of the action of the ne before him. To let a student calculate many examples of the total of steam on a piston may be good, but he gets no clear idea of what rs unless familiar illustrations are given to him of the effect of actual s. What is the work done by the steam that comes into a cylinder. we can determine the pressure at every instant by means of the ator. How natural it was for Watt to desire this knowledge. cated power. What sort of information is given by the indicator as to way in which the slide valve regulates the admission, cut off, release, compression. A very short account of how advance and lap enable the e to do this will readily be understood if the teacher allows the ents to change for themselves the advance on the model, and especially e valve has an adjustable lap.

would be unfair, now, to the students not to let them see how a link on enables an engine to be reversed, for as they notice locomotives will desire this knowledge, and they ought to be shown a model of a motion and indeed as many other models as are available, and told to examine in a real engine. It must now be pointed out how strong part of an engine must be made ; why the details are as they are. governor. The fly-wheel.

ie construction of any boiler ought now to be given. Its strength ; heat is given to the water ; the safety valve and other fittings ; how eed water is supplied by a force pump. Other forms of boiler ought e described briefly, but some one kind of boiler ought to be well known ie student, because the careful study of the various parts of one boiler make him familiar with the principles underlying the construction of A good teacher will take advantage of the surroundings of his ents.

t all the following be taught in connection with the engine, boiler, their details. Water carried with the steam ; condensation in the der ; why we have two and three cylinder engines. Drainage ; steam ts ; superheating. A good teacher will give sound notions of how the iples of chemistry and physics are applied, as he describes the engine oiler. The students naturally take an interest in the quantity of air is needed for combustion and in the amount of heat obtainable per d of coal.

l this time the student has not only been listening to lectures and ing numerical exercises, but he has also been testing things for himself. a little boiler, pressure gauge, and thermometer (whose construction ight to understand), he will measure some of the properties of steam get sound notions about latent heat. Expansion of solids, liquids, and . The law of gases as to pressure, volume, and temperature. There simple apparatus for measuring the calorific value of a pound of coal cubic foot of coal gas, but good ideas may be conveyed to students in roughly correct experimental way. Students ought to be able to give count of the various classes of work done by engines, and how it is they have different forms to suit different circumstances.

sketch of the history of the steam engine may be given, and entally of heat engines in general. Particular attention must be paid att's ideas as to the need of a condenser, and how we are still working e same problem—getting rid of cylinder condensation. The air-pump. nd surface condensers.

A short account of the gas engine ought to be illustrated by a sectional working model. Students ought to have fairly clear notions of how the energy of one charge is disposed of; so much to the water jacket: so much to the exhaust, and so forth. Attention must be drawn in the oil engine more particularly, to the entrance of a fresh explosive charge, and to some of the properties of burning oils.

If a teacher has caused a student to take an intelligent interest in a steam or gas engine when he sees one, it will be the business of the Examiners to pass him. It is the business of the teacher to make a student think for himself.

STAGE 2.

Candidates will be expected to have an advanced knowledge of the construction, general proportions, and working of ordinary steam boilers, steam, gas, and oil engines, and the properties of water, steam, and gases: of the details of cylinders and their fittings, connecting and eccentric rods eccentrics, governors, fly-wheels, starting and throttle valves, pumps and injectors. Valve setting. The indicator, condensers, pressure and vacuum gauges, safety valves.

They must be able to work problems (using some diagrammatic or other method) on the slide valve, and steam distribution in the cylinder. Given lap, inside lap, advance, and half travel, to find, for example, the hypothetical indicator diagram. The influence of ratio of length of connecting rod to length of crank in modifying steam distribution. What is the effect of angularity of the connecting rod. Link motions, radial and other valve gears. Why a large engine looks more complicated than a small one, but is really simple. Balanced valves, piston valves, double ported valves.

Some one form of valve motion in which the amount of expansion is controlled by the governor ought to be carefully studied; for example, a cut-off valve on the back of an ordinary slide valve, or a Corliss or some form of tappet motion.

The various forms of energy; mechanical, heat, chemical, and others. Even if the teacher knows that certain subjects are not likely to be required for the examination, he ought to speak of them if they interest his students. No better example can be given than this sort of one: An engine drives some shafting which drives a dynamo machine working electric lights; how do we dispose of the 12,000,000 foot pounds of energy of one pound of coal? [Students ought to get used to stating all kinds of energy in foot pounds.] How much leaves the boiler. How much is indicated in the cylinder; how much leaves the crank shaft; how much reaches the dynamo, how much leaves it; how much reaches the lamps to be given out by radiation. It is very important that students should have exact notions about the transformation of energy. Joule's equivalent. The conversion of water into steam; pressure, temperature; scales of temperature; latent heat, heat energy in general. Radiation, conduction, convection.

The candidate should have a general knowledge of the composition and qualities of the leading classes of solid and gaseous fuels, and their evaporative powers; of the character, weight, and temperature of products of combustion; weight of air required; smoke and smoke prevention; mechanical stoking; chimney and forced draughts.

Why the steam engine maker speaks of water per hour rather than of coal per hour. If the steam leaving the boiler possesses, say, 75 per cent. of the energy of the coal, why does a perfect steam engine utilise so little of it? Elementary notions about the second law of thermodynamics; efficiency of heat engines, and the use of the temperature—entropy diagram for showing more or less condensation during adiabatic expansion: Only an elementary knowledge of theory will be expected, but a student must be

able to make practical use of the diagram. A candidate must know how the practical tests of the working of actual steam engines are made; for example, to find the indicated steam, and to compare it with the feed water. He must have some knowledge of the actual results which have been obtained as to water per hour per indicated and brake horse power, and Willans' rule.

Clear notions of what is wanted in a governor, and how both the fly-wheel and the governor control an engine. What is the effect of a load on the spindle of a Watt governor. Candidates must have a clear elementary knowledge of the forces required to produce reciprocating motion; let them make muscular tests on, say, a truck on wheels, moving it backward and forward; let them observe a weight vibrating at the end of a spring, and make simple calculations; or let them get their knowledge in some other experimental way. Why is there vibration of an engine bed. Let them rotate a body that is out of balance, and let them put it in balance. Let them illustrate with a model the balancing of a locomotive. The steam turbine ought now to be brought to their notice.

They ought to be able to give figures showing the usefulness of expansion; thus to know how to calculate roughly the work done per cubic foot of steam taking a hypothetical diagram; and what are the limits which condensation, friction, and back pressure set to the value of expansion.

The use of the indicator; the errors to be expected; the use to which a diagram is put; how the diagram reveals the peculiarities and defects of the working. Clearance, and how it is measured experimentally or otherwise. Placing the three diagrams of a triple cylinder engine on one sheet of paper to the same scales. Condensation and evaporation going on during expansion. Cushioning.

Generally, candidates are expected to be able to apply the fundamental principles of Heat and Mechanics to steam, gas, and oil engines, and to make calculations such as:—when a quantity of heat is given to a pound of any kind of gas, at constant volume or at constant pressure, or at constant temperature, what changes occur in the stuff.

The details of the construction and action of some one gas or oil engine must be fairly well known to students; and how its performance may be tested.

STAGE 3.

Candidates may be asked questions on the subjects of Stages 1 and 2. Their knowledge of details such as pipe and cylinder joints, the proportions of cylinders in compound and triple expansion engines, cranks, eccentrics, connecting rods, cross-heads, slides, pistons, stuffing boxes, piston rods, flywheels, lubricators, valves and cocks of all kinds, valve gears, jet and surface condensers, air pumps, injectors, ejector condensers, and boilers, must be much more advanced than what is required in the preceding Stages.

They must know graphical or other methods of working problems in link motions and radial valve gears, giving proofs of the correctness of their methods.

They must know how the forces at the two ends of the connecting rod and the turning moment on the crank shaft are affected by the acceleration of the various parts which are in motion.

They must have studied the strength of a strut loaded laterally; for example, a coupling rod when its centrifugal force is considered.

They may be asked to calculate the work to be done by engines in pumping, haulage, for factory purposes, in the propulsion of ships, and in other common cases.

Generally, they are expected to have such a theoretical knowledge of steam, gas, and oil engines, as can be comprehended by candidates who can apply their knowledge of the Calculus to such problems as:—"From "general principles, and the laws of Thermodynamics, find the heat given to "fluid when its state alters." There must be no vagueness in their knowledge of the Thermodynamics of these engines; candidates must be able to

calculate amounts of heat, work, entropy, pressure, &c. For example, the must know the theory of the temperature-entropy diagram, and the problems which we can work by means of it; the proof of the relation between latent heat, change of specific volume, pressure and temperature of steam; the proof of the rules which we use in studying the heat reception in the compression, ignition, and expansion parts of the gas or oil engine diagram.

The transmission of power by compressed air; refrigerating machines, &c.

Candidates are supposed to know how an ordinary engine sets up vibrations in the ground, or a ship, or in itself and the train and bridges if it is a locomotive, and the balancing of engines. Why we aim at quickness of natural frequency in the more modern indicators. How we calculate the natural frequency of an indicator. The errors to be avoided or expected in indicator diagrams.

What goes on inside a cylinder is so complicated that a candidate cannot be expected to have a very definite knowledge, but his knowledge of theory ought to be such that he has definite notions of the effect of drawing away the water, of exposing surface, of range of temperature, of the conductivity of the metal, of using higher speeds, of the usefulness of a steam-jacket and of superheating the steam. Thus, for example, he ought to be able to see how the Willan's rule may be deduced from the ordinary formula of work done per cubic foot of steam which we obtain from the hypothetical diagram.

Safety valves and other fittings of boilers, force pumps, feed water heating, forced and chimney draught, the efficiency of boiler flues.

The candidate must have a knowledge of many kinds of fuel, and he must be able to apply some chemical knowledge as to combustion, dissociation, &c., to practical problems in furnaces, flues, and gas and oil cylinders.

Candidates will be expected to know the construction of the various types of modern boilers and steam engines.

The examination questions will be framed to test the actual knowledge of a student. He must therefore not only listen to lectures and read books and work exercises, but he must experiment with models (as, for example, in valve gear problems), with a small fly-wheel, with an adjustable governor, with balanced and unbalanced parts of machines, with apparatus to give him a knowledge of the properties of water-stuff and gases, and how the walls of a boiler flue or a surface condenser tube allow heat to pass through; with the friction of a slide valve; with what the actual forces are which act at various points in an engine.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or Honours, Part I.)

A knowledge of the best current literature on the subject of steam, gas and oil engines, and the mechanical, physical and chemical properties of water-stuff coal, water, producer and other gases and burning oils.

The application of graphical and algebraical calculation to the more difficult problems in the subject. Most of these problems are stated under Stages 1, 2, and 3. Particular mention may be made of:—The strength of any rod, link, or lever in an engine. What goes on in the cylinder of an engine. Torsional Vibrations of Crank Shafts.

Questions may be asked on the theory, detailed construction, and practical working of engine, boiler, or gas producer, but usually such ob given to candidates as to make it unnecess mere dictionary knowledge of a great didate will be supposed to have a of engines and a general knowle

SUBJECT XXIII.—PHYSIOGRAPHY.

COMPULSORY QUESTIONS MAY BE SET AT THE EXAMINATION.

STAGE 1.

SECTION I.

This Syllabus of Elementary Physiography is divided into two sections, Section I. comprising the main fundamental principles of Physical Science, Section II. comprising the applications of these principles. A separate examination paper will be set in Section I. at the same time that the paper in Physiography is taken. The paper in Stage I. of Physiography will contain questions not only in Section II. but also in Section I., and a certain number of questions out of this last section must be answered in order to obtain a pass in that stage.

The experiments and illustrations in the Elementary Syllabus are given as an aid to teachers. It is desirable that as far as possible the experiments should be repeated by the students themselves. The experiments shown in brackets are supplementary ones.

MATTER.

FORMS OF MATTER.

Solid, liquid, gas. The same kind of matter can exist in all three forms. The transition from one state to another may be sudden or gradual.

EXPERIMENTS.

1. Melt ice and convert the water into steam.
2. Exhibit the softening and melting of sealing-wax.
3. Exhibit and compare the consistency of water, treacle, and softened pitch.
4. Exhibit a coloured gas, such as chlorine or nitrogen peroxide.

INDESTRUCTIBILITY OF MATTER.

EXPERIMENTS.

5. Boil water, condense the steam, and collect the water thus formed.
6. Place a piece of ice in a flask suspended from one arm of a balance. Melt the ice and show that the weight is unaltered.
7. Burn [a candle or] phosphorus in a closed flask [or other apparatus], and show that the weight is unaltered.
8. Dissolve salt in water, and show that the weight of the solution is the sum of the weights of the salt and water.

[9. Connect two flasks containing a little hydrochloric acid and ammonia respectively, by wide glass tubes and an india-rubber tube, which can be closed by a pinch. Weigh. Open the connection between the bottles, and show that the weight is unaltered as the cloud of ammonium chloride forms.]

MATTER OCCUPIES SPACE.

Units of length, area, volume. The metre and the English units of length should be compared and the advantages of the decimal system shown.

MASS.

Quantity of matter. Equality of masses tested by equality of weights. Units of mass, the pound and gram.

SPECIFIC GRAVITY.

Ratio of the weight of a body to the weight of an equal volume of water.

Experiments.

10. Exhibit and weigh equal sized cubes or balls made of wax, wood, metal, or other materials, and show that the weights are different.

11. Show by weighing a piece of plastic material, such as clay or putty, when moulded into different shapes that the weight does not depend upon the shape.

12. Fill two equal flasks or tubes with water and methylated spirit respectively, and show that the weights are different.

13. Fill a counterpoised flask up to a mark on the neck with methylated spirit and water alternately and weigh. Show how to calculate the specific gravity of the methylated spirit.

Law of Archimedes.

Experiments.

14. Show by weighing a lump of putty in water that the apparent loss of weight does not depend upon the shape of the body.

15. Suspend a metal ball of known weight in the air, by a spring balance. Immerse the ball in water and show the apparent loss of weight. Calculate the specific gravity from the data given by this experiment.

[16. Perform a similar experiment using an ordinary balance.]

MOTION, INERTIA, AND FORCE.

Time.

Measurement of time. Division into days, hours, minutes, and seconds. Explanation of the division in reference to the earth's rotation.

Experiment.

17. Make a pendulum to beat seconds and measure its length in inches or centimetres.

Velocity.

Definition of velocity, and measurement of uniform linear velocity.

Inertia and Force.

Any body if not acted on by force is either at rest or moves with uniform velocity in a straight line.

Definition, properties, and representation of force.

The Parallelogram of Forces.

Experiments.

18. Attach a scale of inches to the edge of a blackboard. Obtain two pieces of thin india-rubber cord 20 inches long, and fasten small loops of string to the two ends. Pin one of these loops to the board, so that the upper end of the india-rubber cord coincides with the zero of the scale. Attach the upper end of the other indiarubber cord to any convenient point on the board. Bring the two lower ends together and hook on to them a weight (say of 100 grams). Measure off 20 inches from the upper end of each cord. The excess of length in each cord will be proportional to the tension of that cord. Complete the parallelogram with chalk, and show that the diagonal is vertical and is equal to the extension of the cord when it hangs vertically by the side of the scale with the weight attached.

This experiment may be performed better, and almost as simply, by substituting for the india-rubber two spiral springs made by winding wire round a pencil or other small cylinder; and instead of using india-rubber cords the weight may be supported by ordinary strings passed over pulleys attached to the edge of the blackboard, the forces being measured by weights attached to the other ends. The pulleys must revolve with very little friction.

[19. A jointed parallelogram of wood, one angle of which slides along he diagonal, and of which the diagonal and sides are divided into a umber of equal parts may be applied to the strings to prove that the irection and magnitude of the resultant is given by the rule.]

Parallel Forces.

e resultant of a number of parallel forces is numerically equal to the of those which act in one direction, less the sum of those which act in pposite direction.

Experiments.

20. Suspend a light stiff rod by a string, fastened to the middle point f the rod, which passes over a pulley, and has attached to its other nd a weight equal to that of the rod. Fasten a spring balance (or ttach a string passing over another pulley) to a convenient point on he rod. Suspend weights at the extremities of the rod so that they alance about this point, and show that the magnitude of the resultant s equal to the sum of the weights.

21. Attach an additional weight to the string which is fastened to he centre of the rod and also weights to the ends, so that the rod is in quilibrium. Show that the pull on the balance is equal to the ifference of the forces which act downwards and upwards respectively.

22. Exhibit levers of different kinds in equilibrium under the influence f various forces. Downward forces are of course produced by attach- ng weights, upward forces either by weights attached to strings which ass over pulleys, or by spring balances attached to the levers, or by pring letter balances upon which given points of the lever rest.

23. Exhibit and illustrate the action of the simple pulley. Show hat the tension of the string is less than when the weight is directly upported by the string. Measure the tension either by india-rubber see above) or by a spiral spring, or by passing the string over a fixed ulley and suspending a weight equal to the tension.

24. Arrange a hinged board with a weight attached by elastic to the ree end. Show that the tension is less when the weight rests on the lanting surface of the board than when the weight is suspended freely. ive a general explanation illustrated by the parallelogram of forces.

[25. Wrap a piece of paper round a cylinder which it just fits. Hold t in position by elastic rings. Draw upon it a spiral curve. Unwrap he paper and use it to illustrate the relations between the inclined lane and the screw.]

[26. Exhibit and explain one or two simple combinations of levers nd screws.]

Centre of Gravity.

thods of determining its position.

Experiments.

27. Hang up wooden or cardboard triangles, quadrilaterals, &c. by wo corners in turn and find the intersection of the two verticals. epeat the experiment at a third corner and show that the vertical asses through the centre of gravity.

28. Hang up a skeleton cube or tetrahedron, mark the verticals hrough the point of suspension by light wires attached by wax and hus find the position of the centre of gravity.

ROTATION.

Measurement of Angles.

29. Draw a large circle upon a sheet of cardboard, and divide it into 360 equal parts (degrees). Cut two narrow strips of card of a length slightly greater than the radius of the circle, and pin one end of each to the centre of the circle. Show, by placing the strips at different inclinations to one another, the meaning of angular measurement.

Motion in a Circle.

If a body moves in a circle a force must act towards the centre of the circle. If the force suddenly ceases to act the body moves on in a straight line and thus departs from the centre of the circle. Hence the phrase "centrifugal force" has been used to describe an effect which is really due to the inertia of the body. The force which urges the body towards the centre is called the "centripetal force."

Experiments.

30. Attach equal short threads to the outer edge of a circular card with a hole in the centre. Fasten light balls to the free ends of the threads. Slip the card over the upper part of a top while spinning and draw attention to the behaviour of the balls.

31. Fasten a knitting needle with wax to the lowest point of a watch glass. Moisten the glass with soap solution. Slip the needle into a vertical hole in the central peg of the top when it is spinning at a moderate rate. Blow a soap bubble on the watch glass and draw attention to the fact that it is flattened.

[32. If a whirling table is used, springs may be compressed by revolving balls, and other similar experiments performed.

33. A dog chain, of which the two ends are brought together and suspended from and vertically below a vertical rotating axle, will open out into a loop when the speed is moderate, and when the velocity increases the chain will become unstable and subsequently fly round in a nearly horizontal position.]

ENERGY.

Power of overcoming resistance or doing work. Energy of visible motion.

Experiments.

34. A bullet which can be supported at rest by a piece of tissue paper stretched on a wire ring will pierce the paper if allowed to fall on it.

35. A thread which will support a weight at rest will be broken if the weight be allowed to fall.

36. A falling weight attached by a string to a spring balance will extend the balance beyond the point at which it is in equilibrium.

Various Forms of Energy.

Energy may be transferred from one body to another. Example: Impact of balls. A body may possess energy owing to invisible motions of its particles, and energy of visible motion may be transformed into these invisible motions.

There is every reason to believe that these invisible vibratory motions are the cause of Heat, and that this Heat is a form of Energy. This is confirmed by the fact that Heat generally appears when visible motion disappears.

EXPERIMENTS.

37. Cast a piece of lead in the form of a sphere (about the size of a marble) with a neck which expands again. Tie a piece of string firmly to the neck, and while holding the string strike the sphere several times smartly on an iron plate. Test the temperature of the ball before and after the experiment by a thermopile and galvanometer.

38. Hammer a piece of lead, saw wood, &c., and test the temperature of the lead, saw, &c., before and after the experiment.

39. Rub a brass nail or button on a wooden seat, and notice its increase in temperature.

Heat often disappears when motion is produced.

EXPERIMENT.

40. Cooling of compressed air when allowed to escape.

When bodies are electrified they are endowed with energy (termed electric energy) and can produce motion and heat.

EXPERIMENTS.

41. Suspend a pith ball by a dry silk thread between the knob of an electrical machine (or charged plate of an electrophorus) and an uninsulated conductor. The ball moves backwards and forwards.

42. Show the heating effect of an electric current by passing an electric current through a thin platinum wire.

43. Show the motion of a magnet produced by an electric current.

HEAT AND TEMPERATURE.

DISTINCTION BETWEEN HEAT AND TEMPERATURE.

EXPERIMENTS.

44. Mix hot and cold water. No heat is added or abstracted, but the temperature of the mixture is different from the temperature of the two masses of water before mixture.

The amounts of heat absorbed (or given out) by equal weights of different materials when heated (or cooled) though the same range of temperature are in general different.

45. Heat equal weights of lead and water in the same beaker. Provide two other beakers containing equal weights of cold water. Put the hot lead into one of these, the hot water into the other. Stir and note the temperatures.

[46. Show similarly that 1 lb. of water which was at the atmospheric temperature, and has been heated by contact with 1 lb. of iron at 100°, is not so hot as the 1 lb. of water which was at 100° and has been cooled by contact with 1 lb. of iron at the atmospheric temperature. The difference between the temperature in the two cases may be shown by a differential air thermometer if one is available.

[47. Shake up equal weights of water and mercury at different temperatures, and note the resulting temperature. Repeat, using water and turpentine at known but different temperatures. Confirm by shaking up mercury and turpentine. The relative capacities for heat are inversely as the weights, and inversely as the change of temperature.]

Expansion by Heat.

Experiments.

[48. Solder together side by side a brass wire and an iron wire, each about 2 ft. long. Hammer the compound wire straight, and notice how it bends when heated. Fuse a piece of platinum wire through the side of a glass tube, and notice that the glass does not crack on cooling.]

49. Refer to (1) cracking of thick glass vessels when boiling water is poured into them, (2) necessity for leaving an interval between the ends of consecutive rails on railways.

50. Fit with corks the necks of three 4 oz. flasks. Fit tightly into the corks three narrow glass tubes open at both ends. Fill the flasks with water, alcohol, and oil of turpentine respectively. Push in the corks till the liquid stands in each tube at the same height. Put all three flasks to the same depth into a vessel of warm water. Notice that the expansion of the glass causes a momentary sinking of the liquids; that ultimately the expansions are very different.

51. Fit a 2 oz. flask with a tight cork through which a tube passes, the upper end of which is bent down and then up at the end. Clamp the flask so that the end of the tube dips under water in a basin. Fill a test tube with water, and invert it over the end of the tube. Warm the air in the flask, and collect the expelled air in the test tube.

[52. Fit tightly a cork, through which a straight tube passes, into the neck of a 2 oz. flask. Turn over and pass the tube through the cork in the neck of a wide-mouthed bottle containing coloured water. Warm the flask with the hand so as to expel some of the air, and let the liquid rise in the stem. (An air thermometer.)]

[53. Fasten two such flasks together air-tight by a tube bent six times at right angles and containing some coloured liquid in the middle bend. Show that the liquid moves if one flask is warmed more than the other.]

Measurement of Temperature by Thermometers.

Experiments.

[54. Illustrate the method of filling a thermometer bulb and determining the fixed points.]

55. Place a thermometer amongst pieces of melting ice. Also in boiling water. Note the temperature 0° C. and 100° C. (32° F. and 212° F.). Add a little salt to the ice and to the water; note again.

Refer back to experiment 50.

Conduction and Convection.

The invisible movements which produce heat may be transmitted from particle to particle, and are transmitted more easily by some bodies than by others. Good and bad conductors. Heat may also be transferred by the movements of the hot body as a whole. Convection. Convection in fluids due to difference of specific gravity produced by expansion on heating.

56. Wrap a piece of paper smoothly round a brass tube and hold in a gas burner or spirit lamp. The paper is not scorched. Wrap the paper around a wooden rod of the same size, and heat as before; the paper is scorched.

57. Twist an iron and a copper wire together at one end. At about 4 in. from the joint fasten a marble on each with beeswax. Heat the joint in a Bunsen or spirit lamp flame. Notice that the marble on the copper is the first to fall.

[58. Make a short coil of stout copper wire, ¼th inch internal diameter. Pass it over the wick of a candle without touching the wick. The candle is extinguished.]

59. Turn on, but do not light, a gas jet. Hold over it a wire gauze and light the gas above the gauze. Notice that the flame does not strike through. Principle of the Davy lamp.

60. Put a piece of ice in the bottom of a long test tube, weight it down with a piece of lead. Add water above. Hold obliquely and boil the water over a Bunsen flame or spirit lamp flame without melting the ice.

[61. Examine shadow of red-hot poker. Notice that the heating of the air as exhibited by its undulation extends a very little way downwards, showing the air is a bad conductor.]

62. Heat over a small flame a round-bottomed flask full of water. Throw into the water some solid colouring matter, like cochineal, aniline dye, litmus, &c. Notice how the hot and coloured water ascends.

[63. Fasten the end of a candle on to a saucer and light it; pour water into the saucer. Place over the candle a wide cylindrical glass tube, such as a lamp chimney. Notice the extinction of the candle. Repeat the experiment and introduce down the centre of the cylinder a cardboard diaphragm. Notice that the candle continues to burn. Hold some smouldering brown paper near one side of the cardboard, and notice the direction in which the smoke moves.]

Change of State.

Many solids change into liquids, and liquids into gases, at definite temperature. During these changes of state heat is absorbed without rise of temperatures.

Refer to what has been stated under the head Forms of Matter.

The change of state generally involves a change of volume.

Experiments.

64. Notice that ice floats in water. Soften and blow a small bulb on the end of the glass tube. Fill the bulb with water, seal in the gas flame, and put it in a mixture of ice and salt. Observe bulb burst.

[65. Fill a flask with a mixture of ice and water, fit in the neck a well-fitting cork with long narrow tube till the water stands at a certain height in tube. Observe how it sinks as the ice melts.]

66. Put some ice into a known weight of hot water. Notice the temperature when the ice is melted. Determine the weight of the ice by re-weighing the water. Point out that a small quantity of ice requires a large quantity of heat to melt it. Explain the slow melting of snow after a thaw has set in.

67. Pass steam, produced by heating water in a flask, through a delivery tube into cold water. Notice the rapid rise in temperature of the water, and determine the weight of water condensed.

[68. Place a few drops of water between the bottom of a small beaker and a block of wood. Put some ether into the beaker and blow over it with a pair of bellows having a tube fastened to the nozzle. The water will freeze.]

69. Notice the liberation of heat from the steam from a kettle when a cold body condenses it.

[70. Get a very well-fitting, soft, long, and sound cork to fit the neck of a 4-oz. round bottom flask. Boil water in the flask till all the air is expelled. Remove the burner, and cork up the flask as rapidly as possible. Turn the flask over and pour cold water on the top. Also immerse the corked flask in cold water, and observe in both cases the ebullition under diminished pressure.]

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80. Stretch a wire across opening in cap of lantern. Focus shadow of wire on screen. Interpose strip of glass in front of wire and tilt the strip. Notice displacement of part of shadow.

81. Focus on the screen a small circular hole in the cap of the lantern. Introduce wedge of glass and show that the spot is moved towards the base of the wedge. Let the first face of the wedge be oblique to the beam. Put the second wedge with the first, face to face and base to base, so as to form a single wedge of double the angle. Notice the double displacement of the light spot. Put them edge to base; notice the emergent beam is parallel to the incident.

82. Trace out the course of a ray of light which passes through a block of glass by means of pins.

83. Place a glass cell before the lantern and focus it on the screen. Let the surface of the water be visible. Place a lump of ice on the water, observe the streaky appearance of the illuminated part of the screen. Add syrup, alcohol, and hot water, by a pipette. Pour the vapour of ether out of a bottle. Examine shadow of burning gas, of red-hot poker, and of platinum wire through which a current of electricity is passing.

The analysis of light by a prism and its recomposition.

84. Place in front of a lamp or lantern a card with a rather wide vertical slit. Focus the slit with a lens on a piece of transparent paper or on a white screen. Introduce a glass or water prism into the path of the beam, and show that the image is deviated towards the thick end of the prism. Notice the coloured edges of the images. Reduce the width of the slit, or replace it by a narrower one. Show the spectrum. Introduce another similar prism with its refracting edge turned in the opposite direction. Show that the deviation is destroyed, and that the colours recombine.

85. Paint a disc of cardboard in segments of violet, blue, green, yellow, orange, and red: fasten it on a top and spin. Notice the blending of the colours into a grey by retention of images.

86. Make a solution of sulphate of copper, 2 of sulphate to 20 of water. Add ammonia till the precipitate is re-dissolved. Place solution in glass cell. Focus the round hole in lantern cap on screen. Interpose the above solution. Notice pure blue colour. Interpose red glass either before or behind the cell. Notice total extinction of light.

87. Paint sheets of cardboard with various brilliant colours. Send the light, in an otherwise dark room, upon them, and catch reflected light on white sheets of cardboard.

[88. Use the bisulphide prism to produce a long spectrum of a slit on lantern cap. Pass through the spectrum the glass cell containing as many coloured transparent solutions as you have. Notice the shadow of the cell. Pass through the same spectrum various coloured opaque bodies, such as flowers.]

CHEMICAL COMPOSITION OF MATTER.

Mixtures and Compounds.

89. Mix copper powder with half its weight of sulphur. Heat a portion of this in a dry test-tube, and compare the resulting bluish-black solid with the original mixture.

Note.—The copper powder is easily prepared by digesting granulated zinc in a solution of copper sulphate.

90. Show that gunpowder, though uniform to the eye, is a mixture from which the nitre is obtained when treated with water, and the sulphur when treated with carbon disulphide.

124. Illustrate solvent powers of water. Show differences in solubility by weighing out an ounce each of sugar, common salt and powdered gypsum. The quantities of water required to dissolve them will be about 1 ounce, 3 ounces, and 360 ounces (or 2½ gallons) respectively.

125. Show that distilled water evaporated in a clean dish leaves a scarcely perceptible residue. Show the residue left on evaporating an equal quantity of tap water.

126. Show that water dissolves gases. Boil out the gas from common water and show that its chief ingredient is carbon dioxide.

Carbon Dioxide.

127. Make the gas by the action of hydrochloric acid upon marble, also by heating magnesite or magnesia alba in a glass tube.

128. Show that carbon dioxide is heavier than air by pouring it from one vessel to another and testing with a candle.

129. Pass the gas into distilled water and by means of neutral litmus show that the solution is acid but recovers its neutrality when boiled.

130. Test with lime water; point out that no other common gas gives a similar result. Pour a little clear lime water into a large bottle of fresh air, shake it about and show that very slight cloudiness results. Then by means of a glass tube breathe into the bottle and show that the air from the lungs contains much carbon dioxide.

Lime.

131. Slake and mix with water and demonstrate the alkalinity of the liquid.

132. Show that pure lime dissolves in hydrochloric acid forming a solution which is identical with the solution of marble in the same acid.

Silica.

133. Specimens of quartz, flint, and siliceous sand. Show the insolubility of these in water and in common acids.

134. Obtain some "soluble glass." Show its partial or complete solubility in water and separation of gelatinous silica by strong acids.

Alkalies.

135. Specimens of caustic potash, caustic soda, and the carbonates. Show the alkalinity of these substances and the neutralisation of acids with formation of salts, *e.g.*, formation of common salt from caustic soda and hydrochloric acid, evaporating to dryness.

Common Salt.

136. Show its solubility in water and crystallisation in cubes.

STAGE 1.

SECTION II.

THE EARTH, THE SUN, AND THE MOON.

The Earth's Form. The Horizon.

137. Project, by means of candle at the distance of, say, some 10 feet from a white screen, the shadow of a ball. The shadow will be round. If the shadow of the earth were cast on a screen, and it were found to be round, this would be one argument in favour of the earth being a ball. Shadow of earth on the moon during an eclipse.

Carbon—Wood Charcoal.

107. Heat strongly a piece of charcoal in a closed hard glass test tube to show that without air it does not burn.

108. Suspend a piece of glowing charcoal in a bottle containing lime water. Shake up and show the formation of the white precipitate.

109. Show that charcoal floats in cold water. In boiling water charcoal sinks after a time and then never floats again unless thoroughly dried.

110. If a trough of mercury is available fill a large test tube with ammonia gas and show that it is absorbed by a small lump of charcoal.

111. Exhibit the various allotropic forms of carbon.

Iron.

[112. Determine the specific gravity of iron by 15 and 16.]

113. Weigh carefully a capsule containing about 10 grams of iron filings. Moisten with water and dry again in an oven: repeat the moistening and drying several times till the iron is very rusty, then show that there is an increase of weight.

114. Show that iron will burn in oxygen.

Mercury.

115. Show that quicksilver is about 13½ times heavier than water by counterpoising a small bottle, filling it with water and weighing the water. Then replace the water by quicksilver and weigh again.

116. Bend a piece of narrow glass tube in the middle so that the two branches are parallel to each other and each is about two feet long. Fill the bend with mercury and then pour water into one side, when the mercury has risen one inch on the opposite side the column of water will be 13 to 14 inches high.

117. Show that a key or any small object of iron will float on mercury.

118. Show that mercury does not wet glass but adheres to clean zinc or copper.

119. Boil a little quicksilver in a test tube and show that it is volatile.

120. Red mercuric oxide when heated gives oxygen gas and metallic mercury. Do this in a short tube made from combustion tubing. Commercial red precipitate contains traces of nitrate; to decompose this it should be heated strongly in an open dish, and after cooling preserved for use in a bottle.

Water.

Physical properties already shown.

121. Show the action of Sodium on water. A small piece of sodium thrown upon the surface of water swims about with a hissing noise, leaving a solution which turns red litmus blue. To collect the hydrogen evolved in this experiment a piece of sodium the size of a small pea should be stuffed into a piece of narrow compo. pipe closed by pinching at one end. The pipe containing the sodium may be thrown into a trough of water, and the bubbles as they rise collected by downward displacement of water in a small glass jar.

122. Pour about three ounces of water upon ½ lb. of good lime. Observe the evolution of heat and formation of a dry compound.

123. Show specimen of blue vitriol in crystals. Dry some blue vitriol in an oven till white. Water poured upon this white anhydrous substance immediately reproduces the blue compound with evolution of heat.

Dimensions and Density of the Sun.

143. Show that a halfpenny, which is one inch in diameter, will just cover the sun's image when placed at nine feet distance from the eye. Knowing the distance of the sun, its diameter can be calculated by simple proportion.

Inclination of the Earth's Axis and Variation in the Length of Day and Night.

144. Take a knitting needle and incline it at an angle of 23½° on a piece of board, pass it through the centre of an orange, and move the orange round a lamp. When in the position that the inclination of the knitting needle is towards the lamp, point out that a white bead on the upper surface of the orange is illuminated longer than one on the lower surface when the orange is rotated round the knitting needle. Also point out that near the vertical pole a point is always illuminated, and near the south it is never illuminated. Move the orange so that the needle points away from the lamp, and show that the illumination of the southern and northern hemispheres is just reversed. Move the orange half way between these two positions, always keeping the needle pointing in one direction, and show that both hemispheres have equal illumination. Point out that the duration of day and night is analogous to this, and draw the conclusion that the earth's axis must be inclined, and state the actual inclination found by observation.

The Four Seasons.

145. Take two similar thermometers with lamp black on the surface of the bulbs, and place them side by side opposite a bright lamp. Note that they show the same temperature when both are screened from the lamp. Expose one for one minute and the other for two minutes to the rays from the lamp, and show that the mercury in one rises higher than in the other. Repeat the experiment, but change the two thermometers to which the long and short exposures are given to show that the difference in the rise of the mercury has nothing to do with the thermometers. Conclusion to be drawn is that a longer exposure to light gives an increased temperature, and that therefore long days are more conducive to higher temperature than short days.

146. Take two small (say, one inch square) pieces of sensitive albumenised paper side by side, and place one with its sensitive surface vertical and the other inclined at an angle to the vertical. At a position of, say, a foot off, burn two inches of magnesium ribbon, so that the light falls normally on the vertical piece of paper. This paper will be more blackened than the other, showing that light acts most energetically when a surface is at right angles to the direction of the rays. The sun is on an average much higher in the heavens in summer than in winter; hence the light has more power to heat the earth on that account. Point out the connection of these experiments in regard to the four seasons.

The Sundial.

147. Fasten a small rod at right angles to a flat board. Place the board flat on a table, so that the rod is vertical. Move a candle in a semicircle above the table, and note the change in the angle that the shadow of the rod makes.

Refer to the position of the sun in the heavens at different times of the day, and show that the length and angular displacement of a shadow varies, and then proceed to show the reason that the rod, to cast a shadow on a sundial either horizontal or vertical, occupies the angle it does.

The Moon.

148. Take a lath, say, a yard long, and place it on a table, on which also some object is placed at a distance. From each end of this lath point another lath towards the object, and rule two lines on pieces of paper placed between them to show the inclination of the two pointers to the first lath. Make on the blackboard a line to represent the base, and at each end of it draw the angles obtained and produce the lines to meet. The distance measured on the same scale as the base line will give the distance of the object. Show that this is the way that the distance of the moon has been obtained, the diameter, or a part of it, of the earth being the base.

Show how the moon's real diameter can be obtained when its distance is known, and then compare the masses and densities of the moon and the earth. Point out that the moon rotates once a month and travels round the earth in the same period, and hence the same face of the moon is always exposed.

149. Show this practically with a disc of paper attached to a pencil and moved round a lamp. Should there be a moon during this part of the course the class might be shown the different positions it occupies in the heavens at each night at the same time. Explain cause of new and full moon to simple pieces of apparatus.

Lunar and Solar Eclipses.

150. Show the cause of lunar and solar eclipses by using two balls to represent earth and moon and a lamp for the sun, and refer to the fact that the angular diameter of the sun and moon are approximately the same, though of course very different in actual diameter, and explain how this favours the different kinds of eclipses.

Astronomical Measurements.

Point out that celestial measurements must be made in angles. Refer to easurement of angles, p. 140.

151. Place the divided sheet of cardboard flat upon a table, and mark upon it the four cardinal points. Arrange a large pair of dividing compasses upon the cardboard, so that the legs will open in a vertical plane, while the angle between them is at the centre of the circle. Use this arrangement to illustrate the meaning of "altitude" and "azimuth," and to prove that two such angular measures determine the position of a celestial object at any particular moment. Refer to the localization of places upon the earth by means of latitude and longitude.

Subdivision of the Day into Hours, Minutes, and Seconds.

Explain that a Solar day is the interval between two successive southings f the sun at a given place, and illustrate this by reference to sundial bservations. State that these days differ in length during the year, and xplain what is meant by a mean solar day; thence pass to the subdivisions f the day into hours, minutes, and seconds.

THE ATMOSPHERE.

Weight of the air, pressure on the earth's surface, height of the atmosphere. Boyle's law. The principle of the mercurial barometer. Pressure f the atmosphere at different altitudes. Composition of the atmosphere nd the diffusion of gases; animal and vegetable life in relation to the tmosphere. Isobars.

152. Illustrate pressure of atmosphere by a sucker and a syringe and explain the action of a pump.

153. Cover a glass carefully filled with water by a card and invert, showing that the upward pressure of the air on the card prevents the water from falling. Notice effect when air is allowed to enter above the card by pulling it down.

154. Construct a barometer with closed tube, mercury and cup. Show how the length of the mercurial column is measured.

155. Weigh the column of mercury sustained in the barometer-tube and measure the diameter and area of the tube. Calculate from these observations the weight of a column of air on any given area.

156. Take a bent tube closed at one end, and by pouring in mercury at the open end, show that the contraction of air in the closed part of the tube takes place in conformity with Boyle's law. Refer to experiments 99–106, 129–132, in illustration of composition of the atmosphere, and diffusion of gases.

157. Grow mustard and cress seeds on wet flannel, or suspend beans or acorns in a bottle of water to show that plants are built up from materials which exist in the atmosphere.

158. Burn wood, cotton, or other vegetable matter in a bell-jar over lime-water, and show that the products of combustion are water and carbon dioxide.

Atmospheric Phenomena.

The manner in which the atmosphere is warmed and its temperature [illegible] different elevations. Isotherms. Fog, mist, clouds, rain, snow, hail, de[illegible], and hoar-frost. Winds and their causes. Circulation of the atmospher[illegible]e. Land- and sea-breezes; monsoons and hurricanes; trade winds and the[illegible]ir causes. Rain-fall; method of measurement.

Illustrations.

The teacher ought to be able to show his class how the chief kin[illegible]ds of meteorological observations are made. Besides the home-ma[illegible]le barometer, maximum and minimum and black-bulb or dew-poi[illegible]nt thermometers are desirable, with a simple form of rain-gauge. If once a week or oftener, the scholars were allowed to read the sever[illegible]al instruments for themselves, the significance of the various records bei[illegible]g explained, much greater interest would be given to the teachi[illegible]g. Everything will of course depend on the nature of the explanatio[illegible]ns given. Thus in taking readings from the rain-gauge it will be necessary to show that, in order to calculate the number of inches of rain-fall in a district, we must know the exact relation between the area of the collecting funnel and that of the graduated vessel in which the water is measured.

159. Illustrate formation of dew by bringing glass of cold water into warm room.

160. Illustrate condensation of steam and formation of rain by vapour from spout of kettle.

The Sea and Circulation of Water on the Land.

Composition of sea-water. Its specific gravity and freezing point. Proportion of land to water. Division into oceans and seas. Sea-level. Depths of oceans. Circulation of water. Currents in the oceans. Distribution of temperature in the ocean. Springs and rivers.

161. If possible, evaporate a glass or beaker of sea-water and one of ordinary spring-water, and compare residues.

162. Show difference of density of spring-water and sea-water by weighing equal measures on a balance.

The general characters of rivers, deltas, glaciers, and moraines should be explained by the aid of diagrams and drawings on the blackboard.

163. Illustrate currents produced by convection in water by reference to experiment 62.

164. The production of surface currents by wind may be illustrated by the aid of a pair of bellows and a basin of water, with sawdust or other floating particles.

Those portions of physiographical teaching which are based upon obser-tion rather than experiment require the exercise of a certain amount of dgment on the part of the teacher in the selection of his illustrations. A alk by the sea-side (if possible), or along the banks of a river, will give the acher an opportunity of impressing many useful lessons on the minds of is pupils. His rule should always be, never to rely upon descriptions or awings when it is possible to show the real things. Even in cases like the udy of glaciers and volcanoes, the pupils may be brought more in touch ith the subject by being shown glacially-striated stones, or specimens of coriæ, pumice, and volcanic dust. Photographs and photographic lantern lides will be found of great service in teaching this part of the subject.

In the observational portions of physiographical teaching however, xperiments may sometimes be used with advantage, and opportunities of owing such experiments during the class teaching should never be eglected. Suggestions are given of such experimental illustrations in the llowing pages.

In every case the lessons of the teacher on many subjects must be deter-ined by the nature of the district in which the class is taught. Every hool ought to be provided with the sheets of the Ordnance-Survey Map lating to the country round the place at which the lessons are given, viz.: e 25-inch map of the streets round the school, the 6-inch map, and the nch map (two copies, one with contour lines, the other with hill-shading). e Geological Survey Maps should also be used.

Rivers and Glaciers.

Tidal rivers and deltas. Glaciers and formation of moraines. Icebergs.

Although the action of rivers and glaciers cannot be directly shown to the pupils, much may be done in making matters more clear to their minds by simple experiments. The properties of ice should be illustrated by a block, which can be procured from any fishmonger.

165. Show that a block of ice floats in water with about nine-tenths of its bulk submerged.

166. Illustrate regelation by pressing two pieces of ice together in a basin of water, and by supporting a block of ice on two stools, and suspending from it a heavy weight attached to a wire. The wire will gradually cut its way through the ice, which will close up and become united behind the descending wire.

167. Demonstrate the difference in behaviour of ice in small fragments and great masses by means of pitch, sealing-wax, and glass, especially calling attention to the effects of changes of temperature. Rest a stick of sealing-wax on two supports and show that it becomes gradually curved by its own weight.

Illustrate from actual specimens the rounding of fragments by rivers and the formation of pebbles, with the polishing and striation effected by ice.

A ramble on the sea-shore, or even by a river or brook, will give the teacher opportunities for showing the transport and deposition of materials by water.

The Earth's Solid Crust and the Changes which take place in it.

General classification of rocks into aqueous, igneous, and metamorphic. heir characteristics, and common examples of each. Minerals which form cks. Their chemical composition and modes of occurrence.

A set of typical rocks belonging to the aqueous, igneous, and meta-morphic groups should be at the disposal of all teachers of physiography.

A box containing a set of 16 types may be obtained (for 10*s.*). This contains the following:—Angular and sub-angular fragments, pebbles, glacially striated blocks, conglomerate, breccia grit, sandstone, clay, rock-salt, gypsum ironstone, peat, coal, volcanic scoria, and gneiss.

In describing crystalline rocks, it is necessary to show the characters of the chief rock-forming minerals. These should be handed round to the pupils, and their colour, lustre, hardness, cleavage, fracture, and crystalline form pointed out. A box of hand specimens of these minerals can be obtained (for 7*s.* 6*d.*), including—quartz, opal, orthoclase, albite, labradorite, muscovite, biotite, augite, hornblende, calcite, magnetite, olivine, and serpentine.

The chief kinds of igneous rocks should be illustrated by hand specimens, which should be of sufficient size and well selected.

The following varieties should be shown:—Granite, diorite, gabbro rhyolite, andesite, basalt, obsidian, pumice.

Of aqueous rocks the following would be a good selection:—Sandstone, micaceous flagstone, clay, shale, slate, chalk, oolitic limestone, crystalline limestone, dolomite, coal.

Of metamorphic rocks:—Mica-schist, gneiss.

A box containing good hand-specimens of all the above rocks may be obtained (for 20*s.*).

When these rocks are referred to they should be handed round and their characters and constituent minerals described. If possible, they should be placed where the scholars may have access to them, after they have been described, so that they may be examined as often as is desired.

Much new interest will be given to the subject if the teacher has a few microscopic sections of minerals and rocks with an inexpensive microscope to show them. The teacher ought to be able to prepare such sections himself, but (as will be seen from specimens placed in the Science Museum at South Kensington, and issued *on loan* to Science classes) boxes containing a selection of such slides can be obtained for a few shillings.

Changes in the Earth's Crust.

Earthquakes, volcanic phenomena, action of the atmosphere and water. Constructive and destructive action of organisms such as result in the formation of limestone, coral-reefs, and coal. Specific gravity and hardness of rocks. Density of the earth as a whole.

In teaching pupils the nature of earthquake vibrations and the real character of waves of elastic compression, there is nothing so useful as a set of billiard balls to illustrate the communication of motion from particle to particle in solid bodies. Failing these, a set of the large glass marbles, used for playing "solitaire," will serve the purpose admirably. They may be arranged in a groove cut in a piece of wood, but can be shown to a class better if suspended by strings to a frame. Volcanic products, like scoriæ, pumice, dust, &c., should be shown to the pupils, and their difference between such substances as cinders and ash carefully pointed out.

Every class ought to be provided with a microscope (a very small and inexpensive one will be sufficient), and a few mounted specimens of sea bottoms—sands, muds, globigerina ooze, radiolarian ooze, diatomaceous ooze, &c., and these should be shown to the class when the origin of the aqueous rocks is described.

With a cheap balance it is possible to illustrate the principles and methods of determining the specific gravity of rocks and minerals; examples of different density like coal and basalt should have their specific gravities determined before the class.

A small collection illustrating the "scale of hardness" of minerals ought to be in the hands of every teacher.

A good teacher will take his class for country walks, and show his pupils the effects of atmospheric denudation in producing the contours of the surface and the varieties of scenery, as well as in determining the vegetation and the whole characters of different districts, and the sites of villages and towns.

TERRESTRIAL MAGNETISM.

Properties of the Lodestone and Artificial Magnets.

'rimary laws of magnetic attraction and repulsion.

Experiments.

168. Magnetize a knitting needle, suspend it so that it can turn in a horizontal plane. Bring another magnetized knitting needle near to it. Demonstrate the fact that the magnetic properties are chiefly exhibited by the ends. Demonstrate the repulsion and attractions of like and unlike poles.

169. Place a strong magnet at right angles to the magnetic meridian. Put the dip needle in the centre of the magnet so that its plane of motion is parallel to the axis of the magnet. Load the upper end with a little wax, so that it is horizontal. Move towards the poles and demonstrate that a dip is produced.

170. Place over the magnet a sheet of paper on which a circle has been drawn, the centre of which coincides with the centre of the magnet, but the diameter of which is greater than the length of the magnet. Scatter iron filings on the paper, tap it, and draw lines showing the directions of the filings at a number of points on the circle.

The Earth is a Magnet.

Describe generally the magnetic state of the earth and the behaviour of a compass and dip needle at different points of the earth's surface.

Experiments.

171. Exhibit a magnet suspended by a thread so that it is free to turn in a horizontal plane.

172. Exhibit a small dip needle.

STAGE 2.

[ATTER.—Rigidity, elasticity, compression, and torsion.

/AVE MOTION.—Nature of waves in water, sound waves in air, and iation waves in ether. Molecular vibration. Absorption of wave ion. Velocity of sound waves and of waves in ether.

NERGY AND WORK.—Conservation, transmutation, and degradation of rgy. Simple laws of the pendulum.

[EAT AND TEMPERATURE.—Registering thermometers, pyrometers. acity for heat and specific heat. The mechanical equivalent of heat. erimental determinations of the mechanical equivalent of heat.

IGHT.—Propagation, reflection and refraction, the spectrum, spectrum lysis.

'HE ATMOSPHERE.—Atmospheric refraction. Absorption of radiant rgy by the atmosphere. Action of dust and fine particles.

TMOSPHERIC PHENOMENA.—Climate and rainfall. The formation of r. Determination of the dew point. Cyclonic and anticyclonic move- its of the atmosphere. Weather charts. Isobars.

ADIATION.—The infra-red and ultra-violet portions of the spectrum. The rmal, illuminating, and chemical effects of the spectrum. Absorption of k radiation by water vapour and its effects. Causes of the colour of the and sunset effects. Lightning and the Aurora.

SEAS AND LAKES.—Tides, in the ocean and in inland seas, their ca... Courses of tidal waves round the British Islands; spring tides, neap ti... Effect of winds on the sea. Heights and breadths of waves. Modes ... determining depths of the sea. Abysmal deposits. Temperature of t... oceans at surface and different depths; effects of pressure in the ocea... Classification and modes of origin of lakes.

THE EARTH'S CRUST.—The chief varieties of rocks of which it is ma... up. Chemical composition, crystalline forms and physical properties of th... most common rock-forming minerals. Distribution of temperature in th... Earth's crust. Methods of determining temperatures in mines, borehole... etc. Geysers and mineral springs. The formation of mineral veins. Th... distribution and causes of volcanic and earthquake phenomena. Seismometr... and the study of earthquake waves. The great movements that take plac... within the Earth's crust. Folding, faulting, and the production of mountain... structures. Action of rain, rivers, glaciers, and the sea in earth-sculptur... Deposition of sediments and the formation of stratified rocks.

THE UNIVERSE.—Methods of determining the rotation and revolution... precession and nutation of the earth: and its distance from the sun. Sun... spots and faculæ and the sun's rotation. The planets and their moon... periods of revolution round the sun. The law of gravity in the sola... system. Discovery of Neptune. Comets, their nature and orbits. Stars... their classification into magnitudes. Proper motions of stars. Photo... graphic star charts. Variable stars. Double stars. Nebulæ.

TERRESTRIAL MAGNETISM.—The horizontal and vertical components of... the earth's magnetism. Position of terrestrial poles. Variation of the... needle. Diurnal and other variations. Connection between Aurora and... magnetic storms.

STAGE 3.

Candidates in this stage will be required to show a fuller and more exact... knowledge of the subjects comprised in the syllabuses of Stages 1 and 2, ... and in addition to answer questions on the following subjects:—

The form and weight of the earth, and the methods by which these have been determined. The composition of the earth's crust and meteorites, and the light thrown by the study of these on the earth's interior. The nature and classification of meteorites and the resemblances and differences between them and terrestrial rocks. The forms of meteorites, the circumstances attending their fall, and their relation to "shooting stars."

Meteorology and meteorological instruments, with the methods of using them. The phenomena attending thunderstorms and auroral displays, rainbows, halos, mock-suns, &c.

The methods of conducting deep sea observations and the chief result of these studies. The use of the microscope in all branches of geological research.

Principles of spectrum analysis applied to heavenly bodies. Selective absorption. Reversal of spectral lines. Kirchoff's experiment. Stokes's law. Frauenhofer's lines. Solar and stellar spectra. Classification of stars according to their spectra.

Sources of solar energy and the state of our present knowledge of the various phenomena occurring on the sun's surface.

The sun-spot cycle and its assumed connection with terrestrial phenomena. The nebulæ and meteoric hypotheses.

There is no "Honours" stage in this subject, but candidates beyond Stage 3 should pursue their studies by taking Honours in VIII. (Sound, Light and Heat), IX. (Magnetism and Electricity), X. (Inorganic Chemistry), or XII. (Geology).

SUBJECT XXIV.—AGRICULTURAL SCIENCE AND RURAL ECONOMY.

COMPULSORY QUESTIONS MAY BE SET AT THE EXAMINATION.

DIVISION I.

STAGE 1.

INTRODUCTION TO AGRICULTURE AND HORTICULTURE.

The idea of this course is to provide an elementary course on the science of plant life and soil, which will at once interest and instruct the student, and lead up to the intelligent study of Agriculture or Horticulture. The syllabus is not intended to give more than an outline of the course of instruction which is deemed advisable; details being left to the discretion of the teacher. It may be necessary for the teacher to vary the arrangements occasionally, so as to render the teaching appropriate to the season of the year.

Teachers are recommended to let the experiments and observations precede the explanations, and to give the class an opportunity of drawing their own conclusions without suggestion or anticipation. The simplest possible language should be used; it will be found possible to dispense with most of the learned language of text-books. Drawing, and especially drawing to scale, is a great help to the right understanding of the structure of plants and animals. Lecturing, and all forms of instruction in which the class is passive are to be avoided.

PLANT LIFE.

SEEDS.—Examine structure of bean, buckwheat, and maize; soak in water, dissect, and examine with lens; point out protective covering, and solid contents united to embryo. *Conditions of Germination.* Plant seeds in sawdust; keep some wet and others dry, some cold and others warm, some in the light and others in the dark; observe the effect of these different conditions on germination. Completely fill a bottle with water, introduce a few seeds and insert the stopper so as to leave no air in the bottle; keep in a favourable temperature, and compare development with similar seeds in air. *Mode of growth.* Which first emerges from the seed-coat, and which grows most rapidly, the stem or root? The solid matter of the seed is at first the only plant food; a young wheat or barley plant has an empty husk on its root. Subsequent growth demands light, and soil-food. Grow seeds in pots in full light, shaded, and in darkness. Grow seedlings (*a*) in sawdust moistened with water, (*b*) in sawdust moistened with the nutritive solution used for water cultures, and in (*c*) good soil. In each case dry thoroughly and weigh a given number of the seedlings weekly.

ROOTS.—Fix a seedling of scarlet runner in a closed box (kept moist by a wet sponge) so that the main root is horizontal; notice how it responds to the pull of gravity. Take bean seedlings with roots an inch (25mm.) long. Mark each root with transverse lines in Indian Ink 2mm. apart. Place each bean in a thistle-headed funnel, standing in a bottle of water, and let the root grow down the tube; cover the funnel with a watch-glass. Note the distance of the marks from day to day, and determine the region of most rapid growth. Observe where the root hairs occur. With seedlings grown in soil show the clinging of soil to the root hairs. Place the roots of seedlings in contact with a weak solution of eosin, and with water in which carmine is rubbed up. Which is absorbed? Why? Examine the various forms of roots shown by farm crops; the plants having enlarged roots (carrot, turnip, etc.), are those that would grow again the following year.

LEAVES.—Their shape designed to expose the largest surface to light and air. Structure of leaf veins shown in skeleton (rotted) leaves.

Separate upper and under skin, and middle layer containing veins, by dissecting box leaves previously boiled 15 minutes in a 5 per cent. solution of caustic potash. Examine the structure of the upper and lower skin with a lens.

Transpiration.—Put leafy shoots in water coloured red with eosin and keep in a warm room in full light for 12 hours. Observe the red in the leaf veins. Make sections of the stem, and trace the course of the coloured water. If a leaf is constantly receiving water from the soil through root and stem it must also lose water. Take a test tube and a well-fitting cork, split the cork lengthwise, fit the pieces on either side of a straight leaf, like wheat or daffodil, and slip into the test tube. Let the leaf remain on the plant, and note the water collected in the test tube after 24 hours. Take a pot containing a living plant, closely wrap the pot and earth with sheet india-rubber to prevent the escape of water-vapour, and place a glass jar over the pot; observe the condensation of water inside the jar during the day. Take a jam-pot or any other glazed jar, plant in it a young cabbage or sunflower; when established, cover as much of the soil as possible with tinfoil, weigh the pot and plant after watering, and note the loss of water by next day. Make daily weighings and note how the loss varies with sunshine and warmth. Which surface of the leaf loses water most readily? Press fresh leaves between two slips of glass, and note which slip becomes most moist. Plunge a fresh laurel leaf into a tumbler of boiling water, observe that bubbles of air issue from the under surface only. Examine with a lens the upper and under surface of box and other leaves; the openings for the passage of water vapour and the admission of air are generally found on the under side.

Formation of Starch. Keep leaves (tropæolum, primrose, marigold, cabbage, etc.) in the dark for 24 hours, then expose some of these to sunlight for several hours. Dip one of each lot successively into boiling water, into methylated spirit till the green colour is removed, and into a weak solution of iodine (colour of sherry); observe the difference due to sunlight. Show by treating thin starch paste, and slices of potato with iodine solution, that the dark blue colour is due to the presence of starch. Fasten corks, or letters cut out of tinfoil, on the surface of green leaves still attached to the plant; after one or two days remove the leaves, and test as before for the presence of starch. (These leaves may be prepared in summer and preserved in alcohol until wanted.) Expose to sunlight a variegated leaf of geranium, or some other plant, and treat as before; observe that the starch is formed in the green portion of the leaf only. Show that air is needed for starch formation by exposing darkened leaves to sunshine both in air and under water. Smear the under side of a darkened leaf with vaseline, and expose to light; the closing of the pores prevents the formation of starch.

From what substance in the air is starch formed? Fix a darkened leaf in a closed bottle containing a little solution of caustic soda or lime-water and expose to light; no starch is produced. Show wood charcoal, called carbon; how made. Heat starch on an iron spoon—it also yields carbon. Take a few pieces of glowing charcoal on a shovel, which has been strongly heated previously, and then removed from the source of heat. Hold an empty bottle mouth downward over the pieces so as to catch the hot gases coming away. Close the mouth of the bottle with a card, turn over, pour in some lime-water and shake up. Repeat the experiment with starch. Starch contains much carbon. Carbon when burnt supplies the air with a gas, carbonic acid, which turns lime-water milky. Show another source of carbonic acid in the air by breathing through a tube into lime-water.

How Starch feeds the plant. Starch in leaf disappears in the night; what becomes of it? Starch insoluble in cold water, sugar soluble. Show other distinctions. Boil Fehling's copper solution in two test tubes with (*a*) a very little starch paste, and a (*b*) minute quantity of honey. There are agents which convert starch into sugar. Add to thin starch paste a little cold water extract of pale malt, to some more add saliva, keep for some time in a warm place (100° Fahrenheit), and then test as before for sugar. Boil some of the malt extract and saliva, and repeat the experiment. Such agents occur in

the leaf. Gather leaves of peas or tropæolum during the night,* rub them to a paste, extract with a little cold water, and add the extract to thin starch paste, keep a few hours and test as before.

STEMS AND BUDS.—Shew the structure of buds in a head of cabbage, and in the buds of horse-chestnut and sycamore, and trace their subsequent development. Structure of a woody stem ; pith, heart-wood, sapwood, growing layer, bark. The yearly growth in thickness.

Treat cross sections of boughs with iodine solution and show where starch is stored up in autumn.

Healing of wounds on trees. How knots arise in timber. Budding and grafting. Formation of roots from cuttings ; experiment with willow twigs and fragments of watercress placed in water, and with geranium cuttings placed in soil. From what part of the stem do roots start? Creeping stems, above ground and under ground ; strawberry, couch-grass, bindweed. Peculiar forms shown by onion, tulip bulbs, crocus corms, potato. Trace the development of a tulip bulb and a crocus corm from month to month.

FLOWERS, FRUITS AND SEEDS.—The parts of a flower and their uses. The transference of pollen by wind and insects. Catkins. The parts which develop into fruit. Study of fruits ; pods of peas, siliquæ of wallflower, capsules of poppy, nuts of hazel, acorns, apples, gooseberries, plums, raspberries, strawberries, vegetable marrows. Means of dispersal of fruits and seeds.

REVIEW OF PLANT LIFE.—Early dependence on food provided by parent. How the plant obtains, stores, and spends its food. Annuals and biennials, bulbs, tubers, perennials.

THE SOIL.

SOIL SUPPLIES PLANT FOOD.—What has soil to do for the plant? Besides supporting it, and supplying water, it supplies certain parts of plant food. Burn twigs of wood, and dry old leaves, to white ash. The part burned away has been nearly all derived from the air (as carbonic acid and water), the small amount of ash comes from the soil. Plant seedlings in clean washed sand, and in good soil ; the sand is a good support and supplies water, but nothing else ; note the difference in growth.

Besides the things in the ash, the soil supplies one other very important plant food. All know saltpetre or nitrate of potash. All soils contain some kind of nitre. Dissolve a minute crystal of nitre in a teaspoon of water, add a few drops of solution of diphenylamine in sulphuric acid, then pour down the side of the vessel about two teaspoons of strong sulphuric acid and mix. Place some dry fine garden soil in a funnel, the pipe of which is very lightly plugged with cotton wool ; pour water very gradually on the soil, collect the first drops that ooze through and repeat the test with diphenylamine. Nitrate of soda is a common manure. All plants need nitrogen as well as carbon they take it from the soil in the shape of nitre.

HOW PLANTS APPROPRIATE SOIL FOOD.—Roots take up water, with this the things dissolved in water. Illustrate solution by experiments with salt, sugar, etc. Take clear water which has passed through a soil and evaporate to dryness in a glass vessel, show the residue left. Acids will dissolve things that water cannot. Try vinegar on chalk. Show that hydrochloric acid can dissolve a small piece of marble. Place a thin bone in dilute hydrochloric acid, in a few days the bone will be soft and transparent, the phosphate of lime having been dissolved. Let the root of a living bean seedling rest on blue litmus paper, and observe the result. Grow some bean seedlings in shallow earth laid upon a slab of well polished marble ; after six or eight weeks clear away the earth and observe the corrosion of the marble. Roots thus not only take up the things dissolved in the water of the soil, but themselves dissolve some of the solid matter.

*If the leaves are dried at a low temperature they can be preserved for subsequent use.

ORIGIN AND COMPOSITION OF SOILS.—Show how soils may arise by describing the formation of some soil in the neighbourhood. Take the class if possible to see a section showing soil and subsoil. Soils are made up of coarse and fine materials, resulting from the breaking up and washing of older rocks. If coarse material, then many stones, gravel, coarse sand; if fine material, then very fine sand and clay. Boil soil in water for half an hour, and show how by stirring up with water and decanting after a minute or two, the fine matter may be separated from the coarse; repeat the treatment till the water comes clear. Treat 1 oz. of a clay, and 1 oz. of a sandy loam in this manner, and compare the results.

Study the characters of sand and clay. Mould small bricks of wet earth, of sand and clay, measure them, then dry; note any alteration in size when dry, also the looseness or hardness of the dried substance.

Take two vessels of zinc one to two inches in diameter, having a perforated bottom, cover the bottom with blotting paper, place in them 50 grams (about 2 oz.) of coarse sand and dry powdered clay, pour slowly the same quantity of water (about half the volume of the sand) on to each; observe how much comes through in either case. Take two similar quantities of dry clay, place one lot in the zinc vessel as a coarse powder, the other lot in a mortar, moisten with water, and rub with the pestle to a smooth paste, turn this into the other zinc vessel; now fill up each vessel with water, and note what quantity of water drains through. What do we learn from these experiments as to the behaviour of a clay soil? Mention ordinary classification of soils according to the proportion of clay present, and point out the behaviour of these soils when cultivated by the farmer.

Another ingredient of soil, present generally in small quantities, is chalk or limestone; how may this be recognised? Treat chalk and limestone with an acid, observe what happens. Treat various soils with the same acid, and notice if chalk is present. What are these bubbles of gas? Treat any effervescing soil with acid in a bottle fitted with a bent tube, and conduct the gas into lime-water. Chalk not only gives up carbonic acid when treated with a stronger acid, it also does so when burnt. What are the products of a lime kiln? Chalk and limestone are carbonate of lime.

Lime important in soils in many ways. It makes the clay friable. Show boiled clay suspended in water in two vessels, to one add lime-water and note the result. Weigh out 10 grams of a clay soil and reduce it to a thin paste by working it up with distilled or rain water in a mortar. Take a zinc cylinder with a perforated bottom, 1 to 2 inches in diameter, or a funnel provided with a perforated disc, cover the perforated portion with filter paper, and wash the clay paste on to it. Fill up the cylinder or funnel with water. Repeat the operation with a second portion of soil, substituting lime-water for the distilled water. Note the times required for 50 c.c of liquid to percolate through the clay in each case.

One plain distinction between surface soil and subsoil. Why is the upper soil darker? The darkest soils are peat, and turf from meadow; why? The dark substance called humus. Being decayed plant substance it contains carbon and nitrogen. What becomes of the humus? Is there any connection between humus and the nitre? What soils are rich and poor in humus?

STAGE 2.

SECTION A—TILLAGE AND CROPS.

Description of various soils; classification of soils as adopted by farmers. Meaning of the terms "heavy" and "light" as applied to soils. The character of sub-soil. Indications which would enable one to form an opinion as to the nature of a soil and its agricultural value.

The conditions of fertility, the requirements of the plant.

Methods of treating the soil so as to render it suitable for the growth of plants. These methods may be classified as (*a*) permanent and (*b*) temporary improvement. Distinction between the two—more or less arbitrary.

The chief permanent improvements—Drainage; benefits due to; indication that land needs draining; methods of carrying out the operation. Irrigation, favourable conditions. How to determine the suitability or otherwise of the available water-supply. Liming, suitable conditions, its effects. Brief mention of warping, claying, sanding, marling, paring and burning. The increase of humus in soil through the agency of green manuring and laying land down to grass.

Temporary improvements—Tillage, effects on soil—moisture; objects of cultivation; physical condition of the soil of paramount importance. Rules to be observed in the cultivation of heavy and light soils respectively at the different seasons of the year. The management of a bare fallow. The intertillage of crops. The eradication of weeds.

Manuring—general principles, the resources of the farm. Farm-yard manure—its character as a general manure; its influence upon the physical properties of soils; its production and management; factors upon which its value depends. Quantity available upon a farm; how best applied. Conditions under which "town" manure may be profitably employed.

The advantages of feeding animals upon the land. Rules to be observed in folding and grazing. Green manuring. The growth of ameliorating crops.

The common artificial manures; their composition and properties; circumstances under which they can be profitably employed; the soils and crops for which they are best adapted; the quantities used; the time and method of application. Precautions to be observed when purchasing; the unit system of valuation.

A brief description of the principal crops or types of crop, grain, fodder and forage, together with the leading varieties of the same should be given; reference being made to the soils and localities suitable; their place in the rotation or their position as regards other crops; the preparation of the ground, the time and method of sowing, quantity of seed, manures required; subsequent cultivation; harvesting; utilization of the produce; insect and fungoid attacks; and any other marked features connected with them. Cost of production and returns to be expected from same.

The principles of rotation, why rotations have been so greatly modified of recent years. The different methods of cropping as practised in various parts of the country. Circumstances determining which crops should be grown; soil, climate, proximity or otherwise to markets, demand for produce, labour, &c. "Special purpose" farming. Temporary leys. Catch crops and bare fallows, their advantage and disadvantage.

Meadows and pastures; points to be considered before proceeding to lay land down to grass; seeding and general management. Grazing, haymaking, ensilage.

Farm implements and machinery, their construction, use and care.

The cost of manual and horse labour and the number of men and horses necessary to perform the various tillage, and other operations, connected with the growth and harvesting of crops. The amount of work that can be performed in a day.

Section B.—Horticulture.

Soil and Situation.—Conditions which render land suitable to particular forms of horticulture, market gardening, hardy fruit growing, nursery stock, cultivation under glass. Proximity to market or stations; cost of labour and manure. Conditions of tenure.

Arrangements.—Design of a garden to suit particular purposes. Shelter hedges and wind breaks. Water supply. Roadways and paths their construction and management.

Tillage.—The various operations and tools required. Substitution of for hand labour. Drainage. The amelioration of the soil by liming, the incorporation of humus or lightening materials on clay soils.

COMPOSTS AND MANURES. The nature of the materials used in cultivation under glass—loam, peat, leaf mould, etc. Farmyard manure, nature and changes during fermentation. Liquid manure. Artificial manures required to supplement farmyard manure and for special purposes.

VEGETABLES.—The cultivation of the standard vegetables in the open air (1) for show (2) for private consumption (3) for market work. Preparation of land, time of sowing, manures, management, insect pests, harvesting and storing of each crop. The character of the leading varieties of Cabbage, Kale, Broccoli, Cauliflowers, Lettuce, Spinach and other leaf crops; Celery, Turnips, Beet, Carrots, Parsnips, Potatoes, Onions, Peas and Beans, Asparagus and Sea Kale, Tomatoes in the open air. The succession of crops to be adopted in a vegetable garden. Forcing and other devices for obtaining early crops. The growth of Tomatoes, cucumbers, beans, etc., under glass. Mushrooms under glass and in sheds. Succession of crops under glass.

HARDY FRUIT.—Preparation of the land, planting, pruning and root management, manures. Spraying and other means of dealing with disease and insect pests. The leading varieties and their characteristics, of Strawberries, Gooseberries, Raspberries, Currants, Apples, Plums, Pears and Cherries Filberts and other nuts. The laying out of orchard land to get early returns and crops coming on in succession. The renovation of old fruit trees.

Fruit trees on walls. Growing fruit for show purposes.

THE ORCHARD HOUSE.—Varieties of Peaches, Nectarines, Apricots, Figs, Cherries, Apples, etc., suited to cultivation under glass. Vines. Preparation of borders and composts; temperatures required, management of water supply and ventilation. Training and pruning. Insect pests and diseases.

THE FLOWER GARDEN.—Hardy and half hardy annuals. Bedding out. The herbaceous border. The rock garden and hardy fernery. Management of Roses and other outdoor flowers for show.

FLOWERS UNDER GLASS.—The management of certain typical flowers under glass for private use and for market work. Azaleas, Ericas, and other hard wooded plants. Lily of the Valley and similar flowers for forcing. Roses, Carnations, Pelargoniums, Crysanthemums, Ferns and other foliage plants.

SHRUBS AND TREES.—The chief flowering shrubs and their management. Species to use (1) on a wall, (2) as specimens, (3) in a shrubbery. Trees appropriate to ornamental grounds. Nursery methods for raising stock of the more commonly required trees and shrubs.

SEED GROWING.—Saving and storing seed. Cross fertilisation and hybridising. Selection and fixation of new varieties. Improvement of plants.

PROPAGATION.—By division and off-sets. Propagation of bulbous plants. Soft and hard wooded cuttings. Layering. Stocks for fruit trees, roses, etc., and their effects upon the scions. Grafting and budding.

PACKING AND MARKETING.—The grading and storage of vegetable and fruit. Methods of baskets, boxes, trays, etc. Packing materials.

ECONOMICS.— our. Amount of labour which should rden, per 1,000 square feet of glass to ps under glass; coal consumed; fr

Section C.—Animal Husbandry.

The different varieties of farm live stock. Description of the principal breeds of each.

Selecting and judging stock; types of animals best suited for particular purposes.

Dentition of farm animals.

The housing and accommodation of stock at the homestead and in the fields. Buildings should be hygienic and convenient. The style of building most suitable for the different varieties of stock.

The breeding of animals; the principles involved; the kind of animals to breed from; the mating of animals; care of breeding animals, both male and female: parturition, the rearing of young animals. The general management of the different animals upon the farm. The disposal of farm stock.

The feeding of animals; rules to be observed; characteristics of the various foods; rations for the different classes of stock. Economical use of home grown and purchased foods. Methods of mixing and preparing foods.

The duties of the attendants upon stock. The nursing of animals; common ailments. Indications of health and ill-health.

Dairying — different systems; milk selling; cheese making; butter making, &c.; housing and general management of dairy stock; effect of different foods upon quantity and quality of milk. Standards of butter and milk. Utilization of separated milk and whey.

Poultry as an adjunct to the farm; breeds and general management.

Cost of keeping animals under varying conditions. Returns to be expected. Milk yields. Daily gain of animals intended for the butcher. Proportions of carcase to live weight. The use of the weigh-bridge and tape.

The different systems of animal husbandry reviewed. Points to be considered when stocking a farm; how to determine the amount of stock a farm will carry.

Note.—The cardinal principles involved in successful stock keeping as illustrated by the practice of the most skilful breeders and feeders, and by the teaching of modern science, should be discussed and emphasized throughout the course, and the errors to be avoided pointed out.

The economic aspect of the subject should receive careful attention, for it is most important that the student should know what returns may be reasonably expected from stock under varying conditions, and how to ascertain quickly and certainly, whether or not, these expectations are being realised.

DIVISION II.

STAGE 1.

The Syllabus for this Stage is the same as that already given for the Alternative Stage 1 *in Inorganic Chemistry, see page* 52.

STAGE 2.*

Section D. The Chemistry of Plant and Soil.

1. Plant Composition.—Composition of plants, proportion of water and solid matter. Division of solid matter into combustible and incombustible. Percentage of ash yielded by corn, straw, hay, roots, &c. Chemical elements contained in the combustible constituents, carbon the principal. Chemical elements in the ash of plants. Ash constituents which are essential for all plants. Non-essential, yet often useful ash constituents. Distinction

* The experimental work to accompany this stage will be described in the next issue of the Regulations. A set of five Diagrams illustrating parts of the course have been published by the Board, and may be obtained of Messrs. Chapman and Hall.

between essential and non-essential ash constituents, how ascertained. Characteristic differences between the composition of the ash of grain, and that of straw or leaf. Quantities of dry matter, nitrogen, and principal ash constituents, in ordinary crops of wheat, beans, meadow hay, clover, turnips, mangel, and potatoes, in pounds per acre. Classification of crops according to composition.

2. PLANT LIFE.—Chemical elements obtained by the plant from air. Composition of the atmosphere. Substances in air serving as plant food. Assimilation of carbon, hydrogen, and oxygen. Function of the chlorophyll cell. Action of light and heat. Distinction between the nutrition of green plants and those destitute of chlorophyll. Formation of organic matter. Plant respiration. Chemical elements obtained from the soil. Plant transpiration; amount of water evaporated by crops. Assimilation of plant food from the soil. Rain water, its action in the soil. Composition of the solution in a soil. Assimilation of nitrogen; nitrogenous substances in soil acting as plant food. Special nutrition of Papilionaceæ, how proved. Solvent action of root hairs on inorganic materials in the soil; substances specially assimilated in this way. Destination of the ash constituents in the plant. Influence of depth and distribution of roots; differences in this respect in various crops. General differences in the life history of annuals, biennials, and perennials. The storing up of plant food for a second season. The exhaustion of the plant during the formation of seed. General structure and composition of seeds. Germination; conditions essential for. Points to be remembered in sowing seeds on a farm. Chemical changes during germination, conversion of reserve matter into soluble nourishment.

3. SOIL PHYSICS.—Soil considered as a mass of small particles of various sizes. Circumstances which determine the total surface of the particles, and the proportion of the space between them. Influence of occasional porosity of the particles. Mechanical analysis of soils. Hardness, specific gravity, and physical characters of quartz-sand, limestones, clay, and humus; variations in character when wet and dry. Difference in adhesiveness of coarse and very fine sand. Clay consists of particles of extreme fineness, some of which possess the properties of a colloid. So-called "heavy" and "light" soils. Coagulation of clay by lime and salts. Differences in physical characters of soil according as clay is coagulated or uncoagulated. Action of dressings of lime or chalk on heavy land. Humus, its origin; roughly divided into humin and humates. All humates colloid bodies. The principal cementing materials in soil are clay and humates. Effect of humus upon the texture of heavy and light soils. Effects of exposure to weather and of cultivation upon the texture of soils. Formation of "pan" in soils.

The capacity for water of soils when saturated dependent on the volume of their interstices. Rate of drainage from soils of different character. Adhesion of water to surfaces; capillary action. Retention of water by soils when drained dependent on the extent of surface of the particles. Evaporation from soils when saturated; influence of time of year. Evaporation from soils when drained. Circumstances in which water is brought to the surface by capillary action. Influence on evaporation of looseness of texture, of stones, of surface cultivation and mulching, of crops and weeds. Practical application of these facts; effect of ploughing, summer cultivation, hoeing, rolling. Wet and dry soils. Hygroscopicity. Influence of subsoil on soil moisture. Water level in subsoil. Treatment of wet and dry soils. Influence of draining, and of farmyard manure.

Heat from chemical action, example of hot bed and damp hayrick. Amount of heat from this cause. Heat from the sun. [illegible] of atmosphere. Great influence of angle of [illegible] of fields. Mean temperature of the soil [illegible] maximum and minimum temperature of [illegible] air. Influence of colour on amount [illegible]. Specific heat of water, humus, [illegible] soil bolls on

weight and volume; its influence on soil temperature. Conduction of heat by soil constituents; influence of fine or coarse division, loose or firm texture, dryness and wetness. Preponderating influence of water on soil temperature. Loss of heat by evaporation. Warm and cold soils. Effect of draining on temperature. Temperature of the subsoil at various depths.

4. SOIL CHEMISTRY.—Describe the history and formation of some soil in the neighbourhood. Describe sand, its origin and constituents; clay, its origin and constituents; calcareous matter, its origin and constituents; humus, its origin and composition. Distinctive characters of humus originating under different conditions, as leaf mould and peat. Point out the general distribution of plant food among the ingredients of soil. Effect of "weathering" on the inorganic constituents of soil; disintegrating action of frost, solvent action of water containing carbonic and humic acids. Effect of autumn tillage and bare fallow. Effect of vegetation accumulating humus at the surface. Action of animal life, worms, moles, ants, &c., in the soil. Differences between surface soil and subsoil.

The absorptive or retentive power of soils towards ammonia, potash, magnesia, lime, and phosphoric acid. Substances for which soil has little or no retentive power. The absorptive action of humus, hydrous silicates, and hydrated ferric oxide. Influence of lime in assisting the absorption of bases from salts. Difference in the retentive power of various soils. Importance of these facts as regulating the choice and time of application of manures.

Oxidation of organic matter in soils, action of animal life, fungi, and bacteria. Products of oxidation. Formation of ammonia. Origin of saltpetre and nitrate of soda. The nitrifying bacteria; in what part of the soil most abundant. The effect on their action of varying conditions of temperature, supply of water and oxygen, and of basic matter. Effect of tillage on production of nitrates. Accumulation of nitrates during bare fallow. Influence of manure on the production of nitrates. Solubility of nitrates, their removal into the subsoil and into drainage and well-waters. Action of crops in taking up the nitrates in the soil, and in diminishing drainage. Conditions favourable to the diminution of the nitrogenous organic matter of the soil. Conditions favourable to the accumulation of nitrogenous organic matter. The root and stubble residue left by various crops. Special effect of laying down land in pasture, and of the cultivation of deeply rooted leguminous crops. Effect of farmyard and other organic manures. Conditions of soil unfavourable to oxidation; a water-logged soil and peat bog. The marsh-gas fermentation of cellulose. Loss of nitrogen by denitrifying bacteria; the conditions of their action.

Show chemical analysis of a soil, if possible one in the district. Mention quantities per cent. of nitrogen, phosphoric acid, potash, lime, and magnesia found in common soils, fertile and infertile; show their amount in pounds per acre to a depth of nine inches. These constituents mostly insoluble; practical importance of this fact. Nature of soluble matter shown by composition of drainage waters. Action of plant roots upon insoluble inorganic plant food depends on its condition. Illustrate from published experiments that abundance of nitrogenous matter, phosphates, and potash may exist in soil, and yet the crop starve for lack of them. Distinction between active and inactive plant food. The great value of manures supplying food immediately available to the crop; the fertility thus imparted soon exhausted. Distinction between the permanent fertility of a soil and the condition superinduced by high farming. Liebig's law of minimum.

SECTION E.—CHEMISTRY OF MANURES AND CROPS.

1. MANURES.—Object of manuring, the increase or maintenance of the fertility of land. Removal of plant food from land by drainage, crops, and animal produce; return of plant food by rain, and other atmospheric supplies; return in manure.

Application of chalk, marl, or lime, an ancient practice. In chalk and marl lime is combined with carbonic acid, as in soil. Continual removal

of carbonate of lime from surface soil in drainage water Recapitula[te] physical and chemical effects of carbonate of lime in soil. It also ai[ds] decomposition of silicates, neutralises humic acid, promotes oxidation [of] vegetable matter. Lime, how prepared from limestone; its behaviour wi[th] water (hence "quick," or endowed with life); the chemistry of the[se] processes. Chemical effects of lime at first far more energetic than th[ose] of chalk. The conversion of lime into carbonate in the soil. Lime fr[om] dolomite (if this is a local rock), the difference in its composition and acti[on]. Give detailed composition of marls, if these are used locally. Soils a[nd] crops specially benefited by liming. Quantities of chalk and lime appli[ed]. Precautions necessary when quicklime is employed. Distinction betwe[en] basic compounds of calcium and neutral or acid compounds; the lat[ter] produce none of the effects of liming.

Green crop manuring, a complete return of matter extracted from s[oil], plus nitrogen from air (when a leguminous crop has been employed), a[nd] furnishes a large addition of humus.

Farmyard manure composed of liquid and solid excrements plus lit[ter]. Solid excrements are undigested matter; liquid, contain the nitrogen[ous] waste products of the body, principally urea. Distribution of ash cons[tit]uents between them. Comparative value of liquid and solid porti[on]. Richness of manure dependent on character and amount of food, and on the use made of food by the animal. The manure of different anima[ls]; characteristic differences as to proportion of water. Different kinds of litter, their composition and absorptive power. Fermentation of u[rea]. Losses of ammonia in stable, how best diminished. Box feeding, its advantages. Feeding in open or covered yards, its advantages and dis-advantages. Losses by drainage. Liquid manure, its composition; h[ow] dealt with. Formation of manure heap. Fermentation of dung; its nature and results determined by the access or exclusion of air. Lo[sses] in the manure heap, how prevented. Advantages of applying fresh mar[ure] to the land. Composition per cent. and per ton of farmyard manure. Its character as a general manure. Its influence upon the physical proper[ties] of soils. Slow action of the plant food it contains. Advantages of fee[ding] animals upon the land.

Bones, fresh, steamed, and boiled, their composition. Forms in w[hich] employed. Soils and crops most benefited by their use. Quant[ities] applied. Slowness of action.

Superphosphate, the object of its manufacture. Chief materials u[sed]. Chemistry of the process. Meaning of the terms tricalcic, dicalcic, and monocalcic phosphate; also of the commercial "soluble," "reverted," and "insoluble" phosphate. Composition of superphosphate. Its actio[n as] manure compared with bone. Soils and crops most suitable for its use. Quantities applied. The combinations formed by phosphoric acid i[n the] soil.

Basic slag, its origin and composition; crops and soils most ben[efited] by it; conditions of successful use.

Nitrate of soda, whence obtained. Its composition. Nitrates a natural plant food. Soluble, not retained by the soil. Precautions necessary to employ nitrate of soda advantageously. Crops most benefited by its use.

Sulphate of ammonia, origin and composition; changes it undergoes in the soil; comparison of effects with those given by nitrate of soda.

Kainite and other potash salts, their origin and composition. Retention of potash by the soil. Crops and soils most benefited by potash manures.

Other manures, their nature and uses. Guanos, their formation; change of composition with age of the deposit; nature of the nitrogen compounds contained in them. Shoddy and other waste materials of animal origin, meat and fish products. Rape dust. Seaweed. Soot. Gypsum. Common salt. Lime. Other manure constituents, how reckoned.

Relative av[ailable]; quick and slow acting nam[es]. [Time] of application, and quantities. Conditions of soil and

climate which should influence the selection of manures. The return in the crop of the constituents applied as manures. Residues of manures remaining in the soil, their availability for future crops. Composition of drainage waters from manured lands.

2. CROPS.—Show amounts of dry matter, nitrogen, phosphoric acid, potash, lime, and silica, in average crops of wheat, barley, oats, meadow hay, red-clover hay, beans, turnips, mangel and potatoes, and any other crops common to the district, in pounds per acre. Classify as rich or poor in nitrogen, in potash, in silica. Regard separately the part of the crop removed from the field, or sold off the farm, pointing out what procedure exhausts the land most in important ash constituents and nitrogen.

Point out the suitability of different crops for the various climates in Great Britain, and any marked preference of particular crops for a special kind of soil. Show the differences in the root development of crops, their length of period of growth, the feeding power of their roots. What is easy for one crop to obtain is difficult for another. Compare wheat and beans as to their capacity for obtaining nitrogen and silica, and turnips and mangel as to their capacity for obtaining phosphates from the soil. The selection of manures is generally based on the special needs of the crop (not on its composition), and on the character of the soil, a general manure frequently not required. The kind of manure most generally suited to each of the crops on the farm. Show from published experiments the effect of nitrate of soda on cereal crops and mangel, and the effect of superphosphate on barley and turnips. Some crops, as potatoes and pasture, usually require a general manure.

3. ROTATIONS.—Influence of the special tillage, root range, and period of growth of various crops, upon the utilisation or waste of soil nitrogen. Cereals, why commonly called exhaustive. Action of a bare fallow. The so-called restorative crops, as roots, clover, and grass; their various modes of action. Rotations, why adopted. Examples of rotations to suit varying conditions. The use of catch crops. The statistics of the farm: soil constituents sold as vegetable and animal produce under various systems of farming, and returned to the soil as purchased food and manure.

SECTION F.—CHEMISTRY OF ANIMALS AND FOODS.

1. ANIMAL COMPOSITION.—Chief chemical constituents of the animal body. Water. Combustible matter (albuminoids, gelatinoids, keratin, fats). Ash constituents. Composition of nitrogenous matters and fats. Characteristic ash constituents of blood, muscle, and bone. Rothamsted percentage analyses of whole bodies of animals. Alterations in composition from youth to age and during fattening. Composition of the increase while fattening. Proportion of carcase in live weight.

2. ANIMAL NUTRITION.—Essential differences between the nutrition of plants and animals; production of heat and work by animals. The principal constituents of cattle foods. Functions of albuminoids, amides, fats, carbohydrates, and ash constituents, as supplying the animal with heat, mechanical energy, nitrogenous tissues, fat, bone, etc. Products of combustion in the body. Relative heat values of albuminoids, fats, and carbohydrates.

Processes of digestion and assimilation. Action of enzymes as hydrolysers. Particular solvent action of saliva, gastric juice, and pancreatic juice. Action of bile. Difference between ruminants and non-ruminants. Changes which take place in the paunch. Digestion of cellulose. Production of methane. Undigested matter. Absorption of dissolved food. Functions of the blood: nutrition of tissues, supply of oxygen, removal of waste products. Nature of excretions by lungs, kidneys, and skin. Function of heart and lungs.

3. FOODS.—Average percentage composition of the foods ordinarily used on the farm. Proportion of true albuminoids in the nitrogenous matter.

Foods in which amides and nitrates are specially present. Vegetable fats and wax. Percentage of starch and sugars in foods. Pectin, pentosans, celluloses, lignin. Difference in value between immature foods and grain. Influence of the age of a crop, of season, and manuring, on its composition and nutritive value. Influence of haymaking and ensilage on composition; the losses in these operations. Characteristics of the different foods. Foods in which ash constituents are deficient. Use of salt. Digestibility of foods, how ascertained. Digestion coefficients of ordinary foods when supplied to cattle, sheep, pigs, and horses Relation between the digestive power of various animals and the diets suitable for them. Influence of the mechanical condition of the food on digestibility. Digestibility of green herbage, hay, and silage compared. Influence of one food on the digestibility of another.

Nutritive value does not depend simply on quantity of digestible matter. Influence of proportion of water in the food. Proportion of albuminoid to non-albuminoid substance, albuminoid ratio. Different amounts of energy consumed during mastication and digestion; great inferiority of fibrous foods save for heat production. Value for heat represented by digested combustible matter. Value for external work represented by this minus energy consumed in digestion. Value for increase the last named after deducting the losses in tissue production.

4. DIETS.—Water required by different animals at rest and at work. Diet for young and growing animals. Composition of the milk of farm animals. Foods nearest milk in composition. Wonderful assimilating power of young animals. Diet for adult animals. Maintenance rations when at rest: minimum of albuminoids required; combustible matter required for heat production; this regulated by the surface of the animal not its weight. Labour rations: production of internal and external work by the combustion of food; comparative labour value of different horse foods; influence of pace on the economy of work. Diet for fattening animals. Conditions necessary for economic fattening. Returns yielded by oxen, sheep and pigs for food consumed; returns within certain limits the same with varying proportions of albuminoids in rations. Composition of wool. Relation of food to production of wool. Diet for milking cows. Large production by good cow for food consumed. Necessity for good supply of albuminoids in food. Food should vary with milk production. Influence of foods on the composition of milk, and quality of butter.

5. ANIMAL MANURE.—Relative manure values of ordinary foods; these should influence the choice of foods. Constituents retained by the animal under various circumstances. Distribution of nitrogen and ash constituents in the solid and liquid excrements. Manurial value of the constituents of animal manures as compared with the same constituents in artificial manures.

6. DAIRY.—Importance of excellence in the cow for profitable dairy work. The constituents of milk. Quantity and composition of milk from various breeds. Variations in composition, during lactation, morning and evening, in successive stages of milking. Curdling of milk by bacteria; sterilising, pasteurising. Fat globules in milk. Methods of separating cream by skimming, and by a centrifugal machine. Composition of skim and separated milk. Composition of cream. Cream for sale and churning. Ripening of cream. Process of churning; influence of the proportion of fat in cream, of acidity and temperature on the results obtained. Composition of butter-milk. Working and salting butter. Composition of butter. Return in butter from milk employed. Rennet, how prepared and its action on milk, the determination of its strength. Process of curdling. Influence of the quality of the milk, acidity, proportion of rennet, the temperature produced. Composition of curd. Changes which occur, and the agents by which they are produced. Loss to the farm by

STAGE 3.

The first examination in Stage 3 will be held in 1905. Candidates for this Stage must have previously passed in the first class of Sections A and C of Division I., and in one Section (D, E, or F) of Division II. The examination will deal chiefly with the practical aspects of Agriculture. Details will be given in the next issue of the Syllabuses.

HONOURS.

In 1904 will be held the last examination for Honours under the Syllabus issued in the Directory of 1901-02. The first examination for Honours under the new Syllabus will be held in 1906. Candidates for this examination must have previously passed in Stage 3, and have also passed in the first class of Sections D, E, and F of Division II. The examination will deal chiefly with the scientific aspects of agriculture.

HONOURS IN HORTICULTURE.

The first examination will be held in 1905. Candidates must have previously passed in the first class of Sections A and B of Division I., and also in Sections D and E of Division II. The examination will deal both with the practical and scientific aspects of the subject. Details will be published in the next issue of the Regulations.

SUBJECT XXV.—HYGIENE.

COMPULSORY QUESTIONS MAY BE SET AT THE EXAMINATION.

NOTE.—In the examination paper for Stage 1 and for Stages 2 and 3 of Hygiene a certain number of questions on Elementary Human Physiology will be set, and no candidate who fails to satisfy the Examiners in this Elementary Human Physiology can pass in Stage 1 or in Stage 2 or Stage 3 of Hygiene.

ELEMENTARY HUMAN PHYSIOLOGY.

1. The form, position, and use of the bones constituting the skeleton, with a general idea as to the build of the body, as well as the boundaries and position of contents of the various body cavities.

2. The structure and functions of the skin.

3. The structure and arrangement of the heart, chief blood vessels, and the circulation, with a knowledge of the general composition, uses, and phenomena of blood.

4. The structure and arrangement of the lungs, with a knowledge of the [redacted] respiration and the changes resulting therefrom in the blood and

[redacted] structure and uses of the teeth, stomach, and intestines, [redacted] of the process of digestion and assimilation.

structure, and uses of the liver, spleen, pancreas

STAGE 1.

of drinking water; sources of water; otective precautions; effects of impure and ection, storage, and distribution of water; ethods of purification.

2. AIR.—Composition of air ; impurities of air ; movements of air; effects of temperature ; quantity of air required ; mode in which it should be given ; principles of ventilation ; effects of respiration and combustion upon composition of air ; ventilation methods.

3. FOOD.—Classification of food substances ; general principles of diet: quantity of each class of food required ; relative value of food substances; their digestibility ; methods of preparing food ; cooking of food : cooking apparatus ; general composition and dietetic value of meat, fish, bread, vegetables, milk, butter, cheese, eggs, tea, coffee, cocoa, the condiments, sugar and fermented beverages.

4. SHELTER AND WARMING.—Habitations, their general sanitary construction ; cause and prevention of damp ; warming and heating ; sources of heat ; materials of clothing ; principles of clothing for children and adults.

5. REMOVAL OF WASTE AND IMPURITIES.—Removal of excreta and house refuse ; varieties of closets and privies, ash-pits, drains, sewers ; object and construction of traps.

6. SOIL.—General features of soil ; conditions of soil affecting health ; drainage, aspect and elevation ; good and bad building sites.

7. PERSONAL HYGIENE.—Importance of cleanliness ; dangers of dirt ; importance of attention to the action of the skin and bowels ; soap ; objects of the use of soap ; washing and bathing ; habits, exercise, rest and sleep.

8. TREATMENT OF SLIGHT WOUNDS AND ACCIDENTS.—Treatment of cuts, burns, scalds, bleeding, fits, drowning, suffocation, poisoning, bites and stings.

STAGE 2.

In addition to the topics enumerated under Stage 1, the following will be required :—

1. WATER.—Quantity for healthy men, sick men, and animals ; action of water on lead ; characters and classification of drinking waters ; relative values of constant and intermittent systems of water service ; construction and action of water filters.

2. AIR.—Relative value of natural and artificial ventilation ; methods of artificial ventilation ; measurement of cubic space and area ; examination of sufficiency of ventilation ; air space surrounding buildings ; overcrowding on space and in buildings ; chemical and microscopical examination of air. Humidity of air ; formation of dew, mist, rain and snow.

3. FOOD.—Standard, economical and wasteful diets ; energy obtainable from food ; putrefactive changes in food ; methods of preserving food substances ; diseases connected with the quantity, quality, and cooking of food ; parasites introduced with food ; nature and dietetic value of alcohol ; brewing.

4. HABITATIONS.—Materials used in the construction of house walls, roofs and their properties ; foundations and basement floors, damp-proof courses, floors, coverings of walls, wall papers ; fire-places, stoves, grates, products of combustion, hot air and water pipes ; artificial lighting ; angle of daylight illumination.

5. REMOVAL OF WASTE AND IMPURITIES.—Disposal of surface and rain water ; methods of removing and treating sewage ; construction and laying of drains ; drain testing ; effects of sewer gas ; general composition of sewage ; disinfectants, antiseptics, deodorisers.

6. SOIL.—Air in soil ; water in soil ; soil temperature ; mineral and organic constituents ; soils in order of healthiness ; sanitary precautions as to healthiness of site.

7. PERSONAL HYGIENE.—Influence of sex, age, temperament, idiocrasy ; heredity.

8. PREVENTION OF DISEASE.—Prevention of endemic and epidemic diseases.

STAGE 3.

In addition to the topics enumerated under Stage 2, the following will be required :—

1. WATER.—Physical and chemical properties ; sources of water supply ; quantity required ; collection, storage and distribution ; effects of insufficient or impure supplies ; purification of water.

2. AIR.—Physical and chemical properties ; impurities of air and their effects ; quantity of fresh air required for men and animals under varying conditions ; the theory of ventilation, and methods by which it can be secured ; methods of heating and cooling habitations.

3. FOOD.—Classification of the food-stuffs ; the nutritive functions and values of the food-stuffs ; standard diets ; calculation of diets ; diseases connected with food ; the theory and practice of cooking ; the composition of meat, fish, eggs, milk, butter, cheese, flour, bread, biscuits, potatoes, the arrowroots, tapioca, sago, sugar, vegetables, beer, wine, spirits, tea, coffee, cocoa, lime-juice and the condiments.

4. CLOTHING AND EXERCISE.—Materials, selection and construction of clothing ; exercise and the amount which should be taken.

5. SOIL.—The geological origin of soils and the properties which influence climate and health ; soil in relation to special diseases.

6. HABITATIONS.—Sites and the general principles of constructing habitations ; special features connected with the construction of artisan dwellings, schools and hospitals.

7. DISPOSAL OF SEWAGE AND REFUSE.—Composition of sewage and refuse ; methods of removing them ; drains and sewers ; disposal and treatment of sewage.

HONOURS.

THE EXAMINATION WILL BE PARTLY WRITTEN AND PARTLY PRACTICAL.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage 3 (or in Honours Part I.).

No candidate can obtain Honours in this Subject unless he has previously passed in Stage 2 of Subject XIV., Human Physiology, and (except in the case of candidates who prior to 1896 have obtained Second Class Honours in Hygiene) in Stage 2 of this subject.

Those candidates who answer the questions in the written paper in a sufficiently satisfactory way will be required to undergo a practical examination at a subsequent date. No candidate can be classed in Honours who is not successful in the practical examination.

In addition to the topics enumerated in Stages 2 and 3, the following will be required :—

1. CLIMATE AND METEOROLOGY.—Classification of climates ; causes and conditions which produce climate ; general effects of climates ; acclimatisation ; meteorological observations and their interpretation.

DISEASE.—Nature and origin of infectious diseases ; specific diseases ; the classification and life history of diseased conditions in man ; nature of immunity in infectious diseases ; the natural history of, and methods of preventing infectious diseases.

3. DISINFECTION.—Disinfectants, antiseptics and deodorants; methods of practical disinfection of dwellings, ships, clothing and bedding.

4. VITAL STATISTICS.—Calculation of population, birth-rates, marriage-rates and death-rates; mortality from zymotic diseases; sickness-rates; relation between occupation and mortality; life-tables, their construction and interpretation; the value of statistical facts, averages and methods.

5. OFFENSIVE TRADES AND THE PREVENTION OF NUISANCES THEREFROM.

6. SANITARY LAW SO FAR AS IT AFFECTS HOUSEHOLDERS.—General powers of Sanitary Authorities.

PRACTICAL EXAMINATION.

Candidates will be expected to make a practical examination of a sample of water, air, or food, and to show a knowledge of analytical methods and to be able to interpret results.

SYLLABUSES OF ART SUBJECTS.

Freehand Drawing in Outline.

Two and a half hours are allowed for this Examination.

e chief object of this examination is to test the power of the candidate
aw freely and accurately in outline.

this examination candidates will be required to draw from photographic
sentations or diagrams of flat ornament, such as inlays, patterns on
ry, mosaics and textiles, similar to those shown below.

e drawing (done at the examination), which should be as firm and
t as possible, may be done with pencil, pen, or brush. The drawing
not be of the same size as the example supplied. No ruling, measuring,
ng, or use of instruments is allowed.

Model Drawing.

Two and a half hours are allowed for this Examination.

Each candidate is required to draw on a half imperial sheet of paper the objects placed before him, including the drawing board on which they stand, as they appear from the point of view in which he may be seated, and his drawing is expected to show a knowledge of the effect of perspective in modifying the appearance of the models. Candidates are not required to shade their drawings since marks for the exercise in shading are confined to work done in Drawing in Light and Shade from a Cast, but, if they prefer to do so, they may lightly shade their drawings from models.

No ruling, measuring, or use of instruments is allowed ; but the pencil may be held between the eye and the objects for the purpose of estimating heir apparent relative size.

For the examination the groups will be composed of three or more of the geometrical models and vases shown in figs. 1 and 2 placed upon an mperial drawing board.

N.B.—Models and vases indicated in the accompanying figures must be of the sizes given below.

Cone (No. 1.) Base, 10 ins. diameter ; axis, or altitude, 15 ins.

Ring (No. 2). Outside diameter, 12 ins. ; section, 1½ ins. by 1½ ins.

Square Prism (No. 3). Edge of base, 7½ ins. ; length or altitude, 15 ins.

White, unglazed, long-necked Bottle (No. 4). Height, 12¾ ins. ; greatest width, 6½ ins.

Cylinder (No. 5). Base 8 ins. diameter ; length or altitude, 12 ins.

Large Solid Cube (No. 6). Edge, 10 ins.

Large unglazed terra-cotta Vase (No. 7). Height, 9½ ins. ; greatest width, 8¼ ins.

Hexagonal Prism (No. 8). Edge of base, 4½ ins. ; length or altitude, 15 ins.

Triangular Prism (No. 9). Edge of base, 8 ins. ; length or altitude, 15 ins.

Square Pyramid (No. 10). Edge of base, 10 ins. ; altitude, 14 ins.

Sphere (No. 11). 9½ ins. in diameter.

Skeleton Cube (No. 12). Outside edge, 12 ins. ; section of framework, 1¾ ins. by 1¾ ins.

Red glazed Vase (No. 13). Height, 10¼ ins. ; greatest width, 7 ins.

Small Solid Cube (No. 14). Edge, 6 ins.

Imperial Drawing Board, 22 ins. by 30 ins.

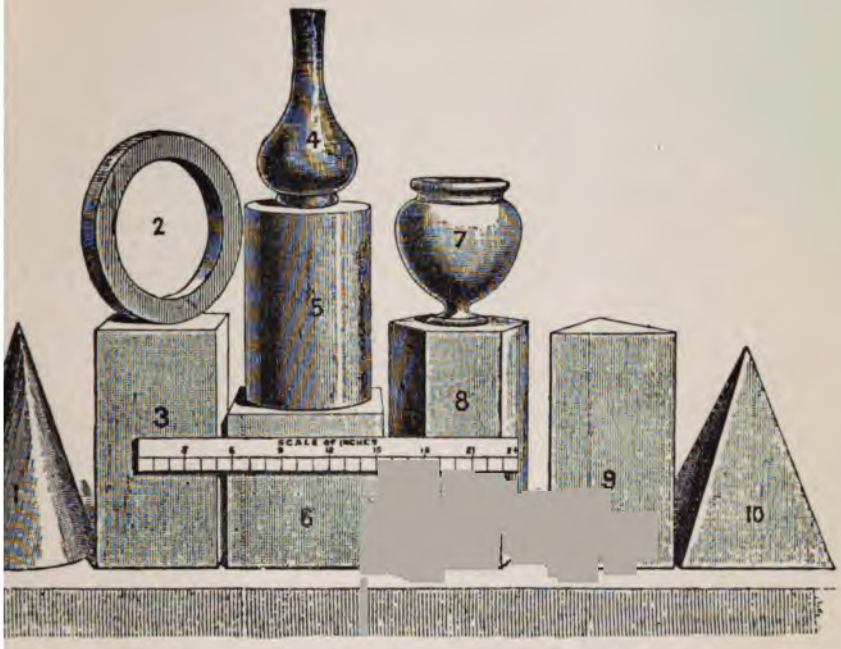


FIG. 1

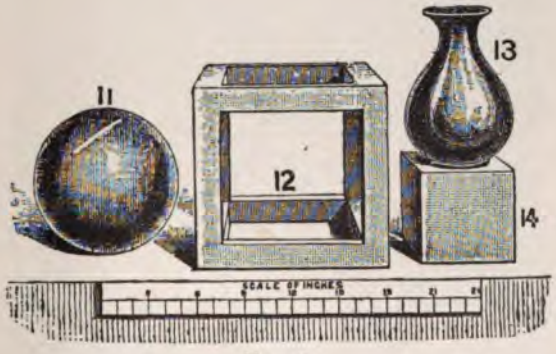


FIG. 2.

Drawing in Light and Shade from a Cast.

Three hours are allowed for this Examination.

Candidates are required to make a shaded drawing on a half imperial sheet of paper from a cast of fruit or foliage or cast of ornament in relief similar to those shown below.

The drawing may be in pencil, chalk, pen and ink, or wash in water colours. The drawing must not be of the same size as the cast. No ruling, measuring, or use of instruments is allowed.

The casts selected for use should be hung before the candidates in such a way that each of them is lighted by only one light. The size of the casts should be in fair proportion to the size of the drawing paper upon which the candidate is required to do his work.

The candidate must show the points and lines by means of which the perspective or the geometrical result is arrived at, and also mark them respectively with the letters above given.

Memory Drawing of Plant Form.

Two hours are allowed for this Examination.

Candidates will be required to draw from memory, in pencil, chalk, or with brush in monochrome, such plants and leaf forms as—

The wild rose, The bay,
The white lily, The laurel,
The field daisy, The oleander,
and others,

giving a simple analysis, from an artistic rather than a botanical point of view, of their chief structural characteristics by sketches indicating the general character and growth of the plant as well as the plan and the profile of a flower, and showing the arrangement of its petals, sketches of the form of its calyx, of its pistil and stamens, also of the various shapes which a leaf takes in its growth, the arrangement of the leaves on the stem, the junctions of leaves on the stem, transverse sections of stems, &c., buds, and seed vessels. In addition candidates will be required to suggest by sketches the decorative adaptation to some definite geometric space, which will be indicated on the examination paper, of the structural and organic characteristic forms as given by the candidate in his analysis.

It should be understood that the plant and leaf forms are mentioned above merely as suggestions and not with any view of limiting teachers and candidates to the study of these particular plants only, but they may be taken as typical and well adapted for treatment in design.

Candidates will, however, be given the opportunity of showing their skill in drawing and analysing other plant forms, and their discernment in having selected such plant forms on account of their appropriateness for adaptation to decorative purposes in flat surface ornament.

Drawing of Common Objects from Memory.

Two hours are allowed for this Examination.

This examination is intended only for advanced students who are thoroughly capable draughtsmen.

The candidate will be required to select and draw one of three or four objects named on the examination paper. The object may be represented in any position the candidate likes. He will then be required to draw the same object in a totally different position and seen from a higher or lower point of view, as he may choose. Finally he will be required to draw a group of three or four objects comprising as the most important object the one originally selected by him.

The objects to be drawn may be *articles of ordinary use*, such as jugs, cans, hats, spades, gloves, boots, hand-carts, clocks, chairs, cupboards, bottles, baskets, candlesticks, lamps, boxes, coffers, pumps, tables, etc.

The drawings may be shaded or not as the candidate prefers. They may be made with either pencil, chalk, or pen, or with brush and water colour in tones of one tint. The drawings must aim at showing good observation on the part of the candidate of each object and of its construction.

The work should be done on two half imperial sheets of paper: (1) for the two first of the exercises; (2) for the final group.

Anatomy.

Three hours are allowed for this Examination.

The examination questions in this subject will be given with the object of testing the candidates' knowledge of certain truths which every representation of the human figure should embody.

The following statement includes the more important subjects upon which the candidates will be examined.

The Essential and Distinctive Characters of the Human Form.

The Skeleton as the framework of the body. The spinal column, with its ligaments, as a whole; its curves; the range of motion of its parts. The skeleton of the thorax as a whole. The range of motion of the ribs and the sternum. The fixation of the spinal column into the pelvis. The inclination of the sacrum and of the plane of the brim of the pelvis to the vertical axis of the body. The differences in the proportions of the pelvis in the sexes.

The connection of the skull with the spinal column and its consequent possibilities of motion.

The skull and the face. Different characters of the skull and face in men, women, and children.

The skeleton of the arm. The normal position of the shoulder blade and the surface reliefs to which it gives rise. The forms of the articulations as influencing reliefs, and limiting the extent and the character of the movements of the parts of the limb on one another, with especial reference to the movements of pronation and supination of the hand.

The haunch-bone as a determinant of form. The skeleton of the lower limb treated in the same way as that of the upper limb. The tarsus (as a whole) and the setting on of the toes.

The Muscles, so far as they determine the outward form of the body. The muscular constitution of the walls of the abdomen; the changes consequent upon various attitudes. The muscular masses of the back and neck. The larynx, so far as it affects the form of the throat.

The superficial muscles of the limbs. The hand and foot compared and contrasted. The area of contact of the sole of the foot with the surface in standing. The "arch" of the foot. The normal positions of the toes.

The brow, eyelids, and visible parts of the eyeball. The nose, lips, and chin. The parts of the externally visible ear. The muscles of the jaws.

The general arrangement of the muscles of the face, and the changes of expression produced by their contraction.

The Proportions of the normal adult male and female; the wholly different proportions of the infant; and the metamorphosis of the infantile into the adult form in consequence of the different modes of growth of the head, trunk, and limbs.

The Figure in Repose.—The causes of the reliefs of the surface of the skin mainly to be sought in the subjacent structures—bone, muscle, tendon, fat, and glands.

The Figure in Action.—The modification of reliefs consequent, directly or indirectly, on the contraction and co-ordination of different groups of muscles.

Candidates will be required to illustrate their answers as fully as possible with good sketches, for which higher credit will be given than for elaborately written descriptions.

Candidates will also have the option of making a drawing of a figure in action, in which the main features in its construction as regards bone and muscle must be clearly displayed.

Drawing from the Antique.

Four hours are allowed for this Examination.

(The examination in this subject may be held only in schools provided at least with four full-sized figures.)

Candidates are required to draw in any point of view which may be selected by the examiner, from the cast of such a figure as that of the Venus of Milo, the Gladiator, the Antinous, the Discobolus, or any modern figure which may from time to time be approved by the Board as an example.

The casts have to be arranged by the superintendents of examination before the candidates arrive.

Candidates' drawings may be executed in chalk or black lead pencil, at least 15 and not more than 18 inches in height, and on a half imperial sheet of drawing paper supplied by the Board.

Candidates are required to place a mark on the right hand of the drawing paper showing the height of the "horizontal line" (to indicate the level of the candidate's eye).

Drawing the Antique from Memory.

Two hours are allowed for this Examination.

Candidates are required to draw from memory any one of the following figures in any point of view which may be selected by the examiner :—

The Standing Discobolus.

The Germanicus.

The Antinous, and

The Dancing Faun.

Candidates' drawings must be at least 15 and not more than 18 inches in height, and may be executed in any method including water-colour, and expressed according to the feeling and discretion of the candidate on the half imperial sheet of drawing paper supplied by the Board.

Drawing from Life.

Five hours are required for this Examination : three hours are allowed for the drawing from the model, one hour for an interval, and one hour for the drawing from Memory.

Candidates are required to make two drawings, a drawing from the nude figure and a memory drawing, which may be executed in any method including water-colour and expressed according to the feeling and discretion of the candidate, on the half imperial sheets of paper supplied by the Board.

Three hours will be allowed for the drawing from the nude figure, which must be posed according to the confidential instructions issued to the Superintendent of the examination. The drawing must be at least 15 and not more than 18 inches in height.

Candidates are required to place a mark on the right hand of the drawing paper showing the height of the "horizontal line" to indicate the level of the Candidate's eye.

When these drawings have been completed, the model will be dismissed from the room and the candidates will be required to make a drawing in one hour from memory of the figure which they have just drawn.

Painting from Still Life.

Six hours are allowed for this Examination, including a rest of half an hour which must be taken by all candidates.

Candidates are required to paint in oil colour, water colour, or tempera, a group of still-life objects such as :—

A pewter inkstand filled with ink, a quill pen standing in it, another quill pen lying on a sheet of red blotting-paper which has been in use; or a plate with two or three oranges on it, and such like groups of objects.

The exercises must be executed on the canvases supplied by the Board.

Candidates using water colours must strain such paper as they are accustomed to use over the canvas, writing upon their paper the examination number which is upon the slip fastened to the canvas. In order that they may do this the canvas may be supplied to them before the time fixed for examination.

Painting Ornament.

Four hours are allowed for this Examination.

The object of this exercise is to test the ability of the student in decorative painting and treatment of form under limited conditions.

The examination exercises are to be executed by the candidates in tempera only, *i.e.*, yolk of egg and vinegar or size-distemper.

A few days before the examination the canvases sent by the Board will be supplied to the candidates in order that they may lay their own grounds, which may be of any colour, red, blue, green or of a neutral tint, provided that that tint be a pure one, such as is made by white and burnt umber, raw umber or terra verte, and that it be a middle tone, neither very light nor very dark.

At the time of the examination each candidate will be supplied with a diagram or photograph from nature which he is to treat ornamentally in such a way as to fill agreeably the given space, such as a square, diamond, lunette, circle, double square, etc.

The design must be painted in three tones of one colour suited to, and in harmony with the colour of the ground, which the candidate has himself prepared.

Historic Ornament.

Three hours are allowed for this Examination.

This Syllabus is intended as an indication to Teachers of the kind of direction which they may take in giving instruction in this subject to students.

The Examination in it is destined to test the candidates' ability to show by sketches and written replies their knowledge obtained not only from various books, but also from studying objects in Museums and Buildings of typical ornamental forms, patterns and schemes of decoration, including Heraldry and Lettering, in use at different periods for

Monuments and Buildings,
Furniture,
Utensils and objects of personal adornment,
Costume, armour, &c.

Candidates will be expected to show an appreciation of the way in which the use of different tools and methods has influenced the treatment of form in the ornament of different races and periods, and to give instances. They will be expected to show their knowledge of typical ornamental treatments (including the mouldings and inclosing lines) of

Horizontal and vertical bands and borders,
Panels of different shapes, medallions or roundels,
Friezes and Pilasters.

I.—Symmetry and Balance.

By "Symmetry" may be understood the harmony of similar masses or lines answering to each other. By "Balance" may be understood an impression of similar harmony produced by the arrangement of dissimilar masses or lines.

II.—Proportion and Spacing.

By "Proportion" may be understood the relation of one part as compared with another or with the whole. "Spacing" may be said to mean the harmonious distribution of forms over spaces.

III.—Subordination.

By "Subordination" may be understood the recognition of the primary importance of constructive elements, the acceptance of the limitations of material or medium, and the sacrifice of some parts to emphasise the importance of others.

IV.—Repose.

By "Repose" may be understood the effect produced by a quiet and dignified treatment in contradistinction to obtrusiveness of detail, or assertiveness of colour; Repose being the result of mutual harmony by the perfect proportion which each part or each colour bears to the rest.

V.—Congruity.

"Congruity" may be said to be the harmonious relation, and agreement between the different parts of an object, or between the complete object and its surroundings.

VI.—Radiation.

"Radiation" is the law whereby groups of lines diverging from a point suggest common origin or growth.

VII.—Contrast.

"Contrast" is the reciprocal effect produced upon two or more forms or colours by their juxtaposition. "Counterchange" is reversal of effect, *e.g.*, that being white which was black and *vice versâ*.

VIII.—Repetition and Rhythm.

"Repetition" is a sequence of corresponding units in any direction. "Rhythm" is the repetition of a sequence of units in a defined arrangement or proportion. "Alternation" is the simplest form of rhythm.

Note.—It will be found that the more abstract a form is the better it will bear repetition; the more closely it approaches imitation, the less suitable it is for such purpose.

IX.—Unity.

By "Unity" may be understood the co-operation of every detail in a scheme to the production of one effect.

N.B.—*These foregoing principles are equally applicable in respect of schemes of colour as well as of form, whether flat or in relief.*

For the purpose of the examination in this subject "Ornament' is understood to mean the embellishment or enrichment of an object.

Such enrichment or embellishment may be effected with the simplest as well as with more complex elements, and will depend for its success upon the application of such principles and laws as those enumerated above.

Direct transcripts from Nature, in which the close imitation of the actual appearance of things has been the first aim, are rarely ornamental in the sense which the term is here intended to convey.

Broadly speaking, for the sake of clearness, ornament may be divided into two classes:—

A. Forms which have no suggestiveness of natural things; those, for instance, in which lines are fitted together or intermixed, so as to make shapes such as plaits, chequers, zig-zags, waved or undulating lines, squares or triangles, circles, ellipses, &c. Such are purely abstract in character, the interest or beauty in them arising chiefly from the correlation of lines and shapes in contrast or harmony one with another.

8. Styles of ORNAMENTAL and DECORATIVE work by artists, such as the Pisani, Ghiberti, Donatello and his pupils, the Della Robbias, Torrigiano, Benczzo Gozzoli, Leonardo da Vinci, Michael Angelo, Raphael, Verrocchio, Rossellino, Benvenuto Cellini, Leonard Limousin, Jean Goujon, Bernard Palissy, Albert Dürer, Holbein, Berain, Boule, Caffieri, Gouthière; Adam, the brothers Sheraton, Chippendale, Wedgwood, Owen Jones, Alfred Stevens, and others, with whose work the candidates may be acquainted.

The Examiners will bear in mind that the majority of candidates can only derive their knowledge of these subjects from books, from reproductions and specimens exhibited in Museums and Collections.

Principles of Ornament.

Three hours are allowed for this Examination.

INTRODUCTORY.

This Syllabus relates to the use of form and colour for decorative purposes. It may be well here to indicate certain directions of study likely to prove beneficial to candidates in the acquirement of an appreciation of principles, and their application to the Arts of Decorative Design.

Their attention is directed especially to—

(*a.*) The General Proportions of Architectural Form and Examples of Ornament, ancient, mediæval, and modern, especially as modified by processes of production and the nature of materials.

(*b.*) Structure and growth of plants, trees, shells, etc.

(*c.*) Lines of growth and motion in animals, birds, ships, waves, etc.

(*d.*) Analysis of form and design, distinguishing essential from subordinate elements.

(*e.*) Geometry as the basis of surface pattern.

It cannot be too strongly impressed upon teachers and candidates that the mere acquisition of terms and laws of design from books is useless to students except as a general guide to habits of keen and accurate observation.

Students should be taught to notice and record, both by careful drawing and slighter sketches, the governing lines in grouped and single figures, animals, floral forms, architectural mass and ornamental schemes.

PRINCIPLES.

Beauty in conjunction with Fitness is essential to good ornament.

The following may be regarded as main principles governing ornament:—

1. Symmetry and Balance.
2. Proportion and Spacing.
3. Subordination.
4. Repose.
5. Congruity.
6. Radiation.
7. Contrast, including Counterchange.
8. Repetition and Rhythm, including Alternation.
9. Unity.

DEFINITIONS.

FITNESS.—By "Fitness" may be understood suitability in all the following directions:—

1. To the purposes which the object to be ornamented is to serve.
2. To the position which such object is intended to occupy.
3. To the material in which the ornament is expressed and to the materials to which it may be applied.
4. To the means wherewith it is to be executed.

and to design them on given lines. That is to say, they may be called upon to make their design a "sprig" pattern, for example, or a "trellis"; or to set it out on the lines of the square, of the parallelogram, of the hexagon, of the diamond; or they may be asked to design it as a "drop."

Again, the pattern may be for a border, straight-lined, geometric, or what not (A, B, C, D, E); or for some particular kind of border, vertical, for example, or horizontal, or in the nature of a frame with corner; or, yet again, the border may be more precisely defined, as a fret, for example, a wave, a border in compartments or one broken by rosettes or paterae, and so on.

he manner of rawing.

III. Drawings, whether for school exercise or for examination, should be not in pencil merely, nor in outline, but in water colour; and the design should be washed in to show dark against the ground, or the ground washed in leaving the design light upon it, with or without an outline. The design may be in black and white or in two tints of colour (not more). In the latter case the two colours should be harmonious or in pleasing contrast. The colouring need not be absolutely flat; but there should be no shading nor any attempt at relief; it should define the design and not confuse it. The drawing should be neither vague nor sketchy, but clean and precise.

Note.—It is not thought necessary to insist, at this elementary stage of instruction, upon the adaptation of designs to execution in any specific material or by any specific process; but the teacher is reminded that the pupil cannot too early have impressed upon him the necessity of considering, in every design he makes, the use or purpose to which it could practically be put.

Stage 2.

Historic style.

I. Candidates for examination must not only have studied the Historic Styles of Ornament, but must be able to make a design for a border (for example, a diaper, a panel, &c.) in the Greek, Roman, Early Gothic (13th century), Renaissance (Cinque Cento), or Moresque manner.

Note.—Such studies will inevitably be more or less in the nature of reminiscences, but teachers should see that they are not reproductions of any existing examples; they should encourage the student to give full play to his own invention, so long as what he does would not appear incongruous or out of keeping with work of the period given.

Conventional treatment.

II.—Candidates must have had practice in making designs for panels pilasters, friezes, borders, spandrils, &c., in which some well-known plant (selected for them) has been taken as a starting point.

Such designs should in every case be adapted to some specific purpose, and to some specific method of execution; and teachers are recommended to insist upon the mention of such purpose and method, in writing, on the margin of the drawing, in order that they may see that the student had a reason, and what reason he had, for the particular kind of convention adopted.

Note.—Here again the study of Historic Ornament will best help to explain what conventional treatment should be;—not that the student will there find natural forms ready adapted for his use, but that he will see how the ancient, mediæval, or oriental workman modified natural form to suit his ideas of ornament.

Applied design.

III. Candidates should be generally acquainted with the various simple processes of workmanship, such as stencilling, colour printing, inlaying, wood carving, modelling, casting, &c., so as to be able to make a design which is practically adapted to execution in a given material or by a given method.

Note.—Teachers should see that the student is never allowed to make a design without a very clear notion as to how, from beginning to end, it could be carried out. There is more to be learnt from making a simple design well suited to its purpose than from elaborating the most ambitious drawing adapted to no purpose or process of execution.

IV. For the Examination candidates will be called upon to make, not merely designs in a given style (as in paragraph I.), or on the basis of a given plant (as in paragraph II.), but original designs adapted to some specific purpose. Original

They may be asked, for example, to make a design for some particular object, for a pavement, perhaps, a ceiling or a frieze, a book cover, a vase, a fan, or what not.

Or they may be asked to make a design adapted to some special process of execution, for inlaying, for process printing, for weaving or embroidery, for embossing, modelling, and so on.

They will have to execute their designs in water-colour; a drawing in pencil or in outline merely will not do. Even though the design be in black and white, it must be washed in, to show light on dark or dark on light, as the case may be.

When the design is for something in relief, the shading must be such as to explain the design, rather than to give the effect of actual modelling: it is a question of design, not of painting. The mar drawing

In the matter of colour there is no restriction, further than what the material or the purpose of the design may suggest; but, as in the case of shading, the colour should not be made use of to obscure the form but to help it.

Honours.

Four evenings of three and a-half hours each are allowed for this Examination, and eight hours for casting the clay models.

Candidates for honours will have to submit either:—

(A.) A scheme of decoration, with some one important feature of it modelled to full size, or to as large a scale as the limits of size (36 in. high × 24 in. wide) will allow; or Subject.

(B.) A panel or other important composition, modelled to full size, or to as large a scale as the above dimensions will allow, with a sketch on paper showing the position the panel or important composition is meant to occupy.

Note.—It is assumed, of course, that Candidates for Honours are competent to pass, or have passed, the examination in the Advanced Stage (or Stage 2).

II. The design must be adapted to some specific method of execution, such as carving in stone or wood, casting, stamping, hammering, or chasing in metal, and it must be specified on the model what that method is. Adaptat

III. The design must include either (1) the human figure, or (2) animal forms, or (3) monsters forming some ornamental feature important enough to occupy a central position in a scheme of decoration. Figure, a

Note.—A *Scheme* of decoration need not of necessity have any relation to architecture: almost any design too comprehensive to be carried out in its entirety in the time allowed for the examination would answer to the term—provided that it were all sketched in, and some important part of it were properly finished.

IV. Models in this stage may be required either in the round or in relief as the examiner may prescribe. Manner Modellin

N.B.—Candidates who fail to conform in any way to the conditions plainly laid down, will forfeit all chance of passing the examination in whatever stage.

Architecture.

Four hours are allowed for this Examination.

I. The students should be taught from the first the influence of constructive conditions and material upon architectural styles, and be made to understand that the character of each style did not result from fancy and caprice, but depended very largely on the social habits of those who developed it, and on the means available of labour and materials.

It should also be impressed on students that it is idle to suppose that architecture can be learned from books and drawings, and that it must be studied from real works; literary study of the subject being only subsidiary to actual experience.

Students should make studies of good specimens of architecture both in the mass and in detail, from buildings of recognised merit. These studies should be drawn both geometrically and in perspective, and the method of construction should be understood and explained by the drawings.

Students should be required to draw mouldings and such details full size, wherever possible, rather than to $\frac{1}{2}$ or $\frac{1}{4}$ of the real dimensions. Managers of schools should note that when they provide casts for the study of architectural ornament they should be accompanied by photographs of the buildings, showing the position and distance of the objects.

II. The Orders Greek and Roman.

The word "order" as applied to classical architecture. Its meaning as a combination of a column and its usual superstructure, or entablature. The term "order" as possessing also a wider significance and extended to denote a style or manner in keeping with one of the varieties of column in use in classic times.

Candidates are expected to make themselves familiar with the forms and general proportions of good examples of the orders, both Greek and Roman, so as to be able to draw them from memory with tolerable correctness, with their proper mouldings and enrichments; but it is not required that the dimensions of the minute subdivisions of height and projection which are met with in the books on the subject should be committed to memory.

III. Students should be taught the differences between the principles of trabeated and arched architecture.

They should be shown how these differences affected Greek and Roman work, and what part was played in Roman architecture by each principle respectively.

The influence should be traced of constructive necessities in developing the subsequent European styles from Roman, and also the influence of the same principle in the development of pointed architecture from round arched.

IV. The characteristics of English architecture from the 12th century, as in the naves of Peterborough, Rochester, Durham, or the transepts of Winchester, down to the 16th century, as in Henry VII.'s Chapel, King's College Chapel at Cambridge, or the Halls of Hampton Court, and of Christ Church, Oxford; and also those of the English variety of Renaissance architecture such as that of Knole, Kirby, Hardwick, and Longleat.

V. Students will be required to describe some buildings in the styles above mentioned with which they are familiar, and will be asked to illustrate their description by sketches from memory.

VI. *General knowledge.* Terms in ordinary use in architectural books.

Candidates will be required to illustrate their answers under this head by sketches.

Architectural Design.

nings of six hours each evening, including a rest of half an hour, i must be taken by all candidates, are, as a rule, allowed for this Examination.

lates for examination in this subject will be required first to uestions upon the safe loads for common materials ; about mortars, of good sand, Portland cement, limes ; about slates and roofing l modes of fastening ; about concreting in floors, roofs, walls, &c., or tiling, spacing of joists, rafters, &c. ; plain carpentry and joinery, g joists and rafters, usual scantlings of timber, proportions of doors, , floors, skirtings, simple linings of doors and windows ; elementary on and warming ; bonds of brickwork ; varieties of rubble masonry ; astering ; plain painting and glazing ; easy plumber's work ; , locks, hinges, fastenings, grates, rainwater pipes and gutters, &c., rainage, connections with sewers and cesspools.

lates will then proceed to design a building, or some portion of a , in conformity with a statement of requirements, or upon a sketch nished to them, and to carry out its architectural treatment in inite style.

ject of this part of the examination is to show that the candidate a competent knowledge of some one style of European architecture proper decorative features and ornaments, and is able to design

igning, it is essential to remember that construction and architec- atment must be considered *together* from the beginning, and that no more fatal mistake than to suppose that the application of t to building converts it into architecture.

king a plan, considerations of access, lighting and conveniency accompanied from the first by artistic arrangements of general or the exterior, and of rooms, staircases and corridors within. it should only be used to emphasise construction or dignify it features outside or inside the building, and *always* with restraint.

its should never be allowed to evade construction difficulties by the oncealed ironwork. If iron construction is used it should be l. But it will be much better that the students should fairly work lems of construction in stone, brick or wood without iron.

me rule applies to half timber work, which, if used at all, should e the real construction instead of being deceptively veneered upon, o, the true walls of brick or stone. But considering the practical is to half timber, even when real, it is better not to employ it at all.

regard to draughtsmanship it should be remembered that cal drawings are not pictures, and should not be treated pictorially, their proper function is to explain the design to the workmen, and them to carry it out. It is pure waste of time to shade elevations ly ; and when an elaborate design or ornament repeats itself in e bays it will be generally be enough to draw one bay completely, dicating the rep etition in the others. Elaborate shading, tinting orial effects should be reserved for drawings in perspective, by udents should always be encouraged to accompany their geometrical

ectural ornament cannot be adequately expressed by drawings in ut should always be shaded. Very slight shading will often suffice e proper expression, and will be better than more elaborate work.

cessary that when proposing examples of actual architecture for to sketch and measure, the master should be most careful to choose ill really educate and improve their taste. To set them to study

inferior examples can do them nothing but harm. It is, moreover, inexcusable, for there is probably no place in England from which some building of merit, ancient or modern, cannot be reached by a short journey by railway or tramcar.

In proposing subjects for design by their students the masters would do well to choose such as have reference to the place in which the school is, and to its industries, rather than buildings of a kind with which the students are less likely to be conversant.

Modelling from the Antique.*

Four evenings of three and a-half hours each are allowed for this Examination, and eight hours for casting the clay models.

Candidates are required to model the subject of the examination of *the same* size *as* the original placed before them, upon a panel about 13 inches by 9 inches.

Modelling the Head from Life.*

Four hours are allowed for this Examination, and eight hours for casting the clay models.

Candidates will be required to model a head in clay in the round from the life, not less than ¾ life size.

The examination is to show the student's capability to construct a head. The work will be judged accordingly.

One day will be allowed for casting.

Modelling from Life.*

Five evenings of three and a-half hours each are allowed for this Examination, and eight hours for casting the clay models.

Candidates are required to model a nude figure in *Alto-relief* upon a panel about 24 inches by 14 inches.

Modelling Design.†

STAGE 1.

The Examination in Stage 1 is suspended.

urface ecoration.

I. Candidates for examination will have to model designs in relief—not in the round—to fit given spaces, such as a square, a triangle, a circle, a spandril, a lunette, a pilaster, a panel, &c. &c.

Such designs may consist of—

A. Ornament composed of straight lines only.
B. Geometric ornament (not confined to straight lines).
C. Interlacing ornament (not strictly geometric).
D. Scroll-work.
E. Foliated or floral ornament.

* This examination is held in schools where candidates themselves are prepared to cast their own models.

† This examination is held in Schools of Art where candidates themselves are prepared to cast their own models.

II. Candidates will have further to design repeating patterns: — Repeated pattern.

A. Straight lined,
B. Geometric,
C. Interlacing,
D. Of scroll-work,
E. Foliated or floral,

and to design them on given lines. That is to say, they may be called upon to make their design a "sprig" pattern, for example, or a "trellis"; or to set it out on the lines of the square, of the parallelogram, of the hexagon, of the diamond; or they may be asked to design it as a "drop."

Again, the pattern may be for a border, straight-lined, geometric, or what not (A, B, C, D, E); or for some particular kind of border, vertical, for example, or horizontal, or in the nature of a frame with corner; or, yet again, the border may be more precisely defined, as a fret, for example, a wave, a border in compartments or one broken by rosettes or pateræ, and so on.

III. Models, whether for school exercise or for examination, should be in relief. The design should be well defined, that is to say, the modelling should be neither loose nor sketchy, but clean and precise. The manner of modelling.

Note.—It is not thought necessary to insist, at this elementary stage of instruction, upon the adaptation of designs to execution in any specific material or by any specific process: but the teacher is reminded that the pupil cannot too early have impressed upon him the necessity of considering, in every design he makes, the use or purpose to which it could practically be put.

Stage 2.

Two evenings of three and a-half hours each are allowed for this Examination, and eight hours for casting the clay models.

I. Candidates for examination must not only have studied the Historic Styles of Ornament, but must be able to make a design (for example, moulding, frieze, capital, a diaper, a panel, &c.) in the Greek, Roman, Early Gothic (13th century), Renaissance (Cinque Cento), or Moresque manner. Historic styl

Note.—Such studies will inevitably be more or less in the nature of reminiscences, but teachers should see that they are not reproductions of any existing examples; they should encourage the student to give full play to his own invention, so long as what he does would not appear incongruous or out of keeping with work of the period given.

II. Candidates must have had practice in making designs for panels, capitals, pilasters, friezes, borders, spandrils, &c., in which some well-known plant (selected for them) has been taken as a starting point. Conventiona treatment.

Such designs should in every case be adapted to some specific purpose, and to some specific method of execution; and teachers are recommended to insist upon the mention by the students of such purpose and method, in writing, in order that they may see that the student had a reason, and what reason he had, for the particular kind of convention adopted.

Note.—Here again the study of Historic Ornament will best help to explain what conventional treatment should be;—not that the student will there find natural forms ready adapted for his use, but that he will see how the ancient, mediæval, or oriental workman modified natural form to suit his ideas of ornament.

III. Candidates should be generally acquainted with the various simple processes of workmanship, wood, stone, and ivory carving, &c., metal Applied de

II. The design must be adapted to some specific method of execution, such as painting (in distemper, &c.), carving (in wood, &c.), engraving, glass painting, chromo-lithography, &c.; and it must be stated, in writing, on the drawing what that method is. Adaptation.

III. The design must include either (1) the human figure, or (2) animal forms or (3) some ornamental feature important enough to occupy a central position in a scheme of decoration.

Note.—A Scheme of decoration need not of necessity have any relation to architecture: almost any design too comprehensive to be carried out in its entirety in the time allowed for the examination would answer to the term—provided that it were all sketched in, and some important part of it were properly finished. Figure, &c.

IV. Drawings may be either in water-colour or in ink; that is to say, they must be executed, either with the brush or with the pen, and must not be merely in pencil.

N.B.—Candidates who fail to conform in any way to the conditions plainly laid down, will forfeit all chance of passing the examination in whatever stage. Manner of drawing.

PART II.

SPECIMEN SYLLABUSES OF SUBJECTS IN WHICH THE BOARD DO NOT HOLD EXAMINATIONS.

SET A. (CONCISE SYLLABUSES.)

Reading or Recitation (or both combined) from a school magazine, or a newspaper, or from some standard author.

Writing and Composition.—Letter writing or commercial correspondence or theme writing (with or without use of typewriter).

Reading and Writing (according to the above Schemes) Combined.

Arithmetic.—Compound rules (money) and reduction of common weights and measures; vulgar fractions; decimal fractions; household accounts, bills of parcels, practice; proportion, its application to interest; averages and percentages.

N.B.—No Scheme may be limited, for a whole session to compound rules (money) and reduction of common weights and measures only, without the special approval of the Inspector.

Knowledge of Common Things.—Brief survey of physical properties of bodies serving to determine their uses and relative value.

Mechanical facts and principles most serviceable in daily life.

Hydrostatic and Aerostatic laws most commonly applied.

Familar notions of sound, light, heat, electricity and magnetism.

Brief survey of the most essential facts and principles of inorganic and organic chemistry.

Leading features of physiology.

Outlines of the animal and vegetable kingdoms, establishing a classified acquaintance with the resources they supply.

The Home, including design and construction on hygienic and economic principles. Materials. Fixtures and furniture. Heating and lighting.

Clothing.—Food and beverages. Cleanliness and disinfection.

Safety from accidents and injuries. First aid to the injured and simple remedies. Means of relief and comfort for the infirm. Precautions against endemic and epidemic diseases.

Discipline of body and mind. Popular influences of music and of the graphic arts. Employments for leisure times.—Household management and thrift. Elementary conceptions on sound principles of social economy.

English Language.—Parsing and analysis of sentences; paraphrasing of simple poetical extracts; history of the English language.

Latin.—Grammatical rules; simple exercises in translation from English into Latin; parsing; translation of a Latin standard author.

Book-keeping.—Commercial terms. Use of cash book, purchases book, sales book. Double entry. Bills of exchange. Bills receivable book. Bills payable book. The journal; its relation to other books. Ledger accounts. Bad debts. Consignments. Discounts.

Shorthand.

Writing from dictation. Transcription of shorthand notes (with or without use of typewriter). Clear and correct formation of shorthand characters and outlines.

Needlework.—Sewing Course.—To cut out garments requiring only straight or slanting lines, *i.e.*, a working woman's apron; a flannel petticoat; an infant's shirt.

To pleat material into bands suitable for use in aprons, woollen petticoats, &c.

To sew on buttons, make buttonholes, and set on tapes.

To make up a complete garment (cut out by the scholar) showing the practical application of the above-named exercises.

To cut out in different sizes garments requiring curved lines, *i.e.*, chemises, drawers, pinafores, boys' shirts (flannel or Oxford shirting).

To gather material and set it into bands, *i.e.*, neck or collar bands, wristbands, &c.

To run and feather-stitch tucks.

To join material on the straight, on the cross, and on the curve by various kinds of seams.

To set in gussets and make false hems.

To make up a garment (cut out by the scholar) showing the practical application of the above-named exercises.

To cut out in several sizes (from measurements) a plain dress bodice and a night-dress.

To set on hooks and eyes, to case bones, to overcast seams, and to bind skirt edges.

To make up a dress skirt, lined or unlined. To make up a simple dress (skirt and bodice) or a night-dress cut out by the scholar.

Knitting and Mending Course.—To knit a man's sock.

To darn thin places on flannel and holes in socks and stockings.

To patch in flannel.

To knit a stocking.

To patch in calico.

To darn and repair house linen, *i.e.*, sheets, tablecloths, &c.

To patch and darn dress materials (print and woollen).

Millinery—Hemming, sewing or seaming and felling.

Hemstitch and drawn threads, Back stitch and long back stitch.
Loop stitch, button-hole stitch, under hemming, slip stitch, pleating, fly-running and gathering frills.
Whip stitch and setting on frill, tuck-running, setting frill into band, coral and feather stitch, sewing on tapes or strings.
Button hole stitch for wiring, also putting shapes together; back stitching, catch stitching, slip stitching, clenching and tying wire, hemming, round hem, flat hem, folds hem, putting on hem, ruching, joining and kilting lace, cutting and hemming crêpe, fly running, drawn casings, flat and round casings, stitches used in straw working, how to stitch on various trimmings.

Vocal Music.—

a.—Staff Notation.—Notes, their shape and value. The treble and bass clefs. Scales and key signatures. Intervals, bars, and time signatures.

b.—Tonic Sol-fa Notation.—The major scale and common changes of key. Pulses, measures, and rhythmic phrases. The minor scale and common chromatics.

The training of the ear and of the voice. The tasteful performance of music.

Geography.—General geography of the British Isles, their chief industries and means of communication by land and water.

General geography of Canada and the United States, or of Europe or Australasia or British India, with special reference in each case to their industries and to their commercial relations with Great Britain.

Colonisation and the conditions of successful industry in the British possessions generally.

History.—(*a.*) Particular periods or subjects, *e.g.* :—

The reign of Queen Victoria. History of the British colonies. The Stuart period, with especial reference to the constitution and functions of Parliament. The expansion of England in the 18th Century.

(*b.*) Biographies of leading persons and the chief events in a selected portion of history, *e.g.*, 800 to 1215 A.D. or 1688 to 1760 A.D.

Modern Languages.—Grammatical rules; easy conversational phrases and sentences; translation of an easy reading book; a letter or theme in French or German. [Fair correctness of pronunciation to be required.]

Euclid.—Books I., II., III., (or parts of those books), with simple deductions.

Algebra.—Some part of the subject so far as quadratic equations and easy problems leading to them.

Mensuration.—Triangles and parallelograms; the circle; spheres, right cone and cylinder; use of the chain and field-book in land surveying; duodecimals; measuring brick-work and timber.

Domestic Economy.—Foods and beverages. Their properties, nutritious values, and functions. Their preparation. Clothing. The dwelling. Rules of health. Washing.

Ambulance.

(*a.*) A general outline of the structure and functions of the human body and its various organs; description of the bones, joints, and muscles, with special reference to those parts which can be recognised externally.

The function of respiration; structure of the lungs; artificial respiration—its application in cases of drowning or suffocation; the structure of the heart; the circulation; the position and the direction of the blood vessels; points where the main blood vessels can be compressed.

The difference between arterial, venous, and capillary bleeding; the first aid treatment of bleeding by means of pressure and improvised methods.

General rules as to the immediate treatment of cuts and wounds; importance of cleanliness. Removal of foreign bodies from the eye.

First aid treatment of faints, burns, and scalds; what to do when dress catches fire; how to remove clothing from injured parts. General precautions to be observed in cases of insensibility and sudden illness.

Triangular bandage—description; its application to various parts of the body.

For Boys and Men Only—

The improvised method of lifting and carrying the sick or injured.

Methods of lifting and carrying the sick or injured.

Their conveyance by rail or country carts.

(*b*). ALTERNATIVE SCHEME—(The scheme of the St. John Ambulance Association. Instruction under this scheme must be given by a duly qualified medical practitioner to the sexes separately.)

A general outline of the structure and functions of the human body including a brief description of the bones, muscles, arteries, and veins.

The functions of circulation, respiration, and the nervous system.

A general direction of the main arteries, indicating the points where the circulation may be arrested by digital pressure, or by the application of the tourniquet. The difference between arterial, venous, and capillary bleeding, and the various extemporary means of arresting it.

The triangular bandage, and its application.

The signs of fracture, and first aid to be rendered in such accidents.

The application of splints or other restraining apparatus. Treatment of sprains.

First aid to those suffering from collapse and injury, to those stunned, to the apoplectic, inebriated, epileptic, fainting, and to those bitten by rabid animals. The immediate treatment of the apparently drowned or otherwise suffocated. Burns, scalds, and poisons. What to do when dress catches fire.

For Boys and Men Only—

The improvised method of lifting and carrying the sick or injured.

Methods of lifting and carrying the sick or injured on stretchers.

Their conveyance by rail or in country carts.

For Girls and Women Only—

Preparation for reception of accident cases.

Lifting and carrying patients. Preparation of bed. Removing patients' clothing. Preparation for doctor's visit.

Home Nursing.

(*a.*) Necessity for knowledge of laws of health, and their practical application. The Nurse,—her duties and responsibilities. Necessity for method and cleanliness. Note-taking; use of charts. The sick room, preparation; furniture; ventilation and warming. The bed and bedding; bed making; draw sheet; changing sheets. Air and water beds. The patient,—clothing and changing; washing; lifting helpless patients; bed rest; bed pan; bed sores; preparation for the night.

Sick feeding: Rules to be observed; preparation of food; sick dietary and cooking; regulation of visits. Administration of medicine. The roller bandage, and its application to various parts of the body. Use of the ordinary and clinical thermometers. Baths,—their use and temperature. How to prepare for the doctor's visit. Poultices; fomentations; liniments; ointment. General rules as to nursing infectious cases. Weights and measures used. Personal and family hygiene; management of convalescents.

(*b*) ALTERNATIVE SCHEME.—(The scheme of the St. John Ambulance Association. Instruction under this scheme must be given by a duly qualified medical practitioner to the sexes separately.)

The Sick Room.—Introductory remarks. Selection, preparation, and cleaning of room. Bed and Bedding. Furnishing, warming, and ventilation.

Infection and Disinfection.—Infectious and non-infectious cases; quarantine of patient. History of a fever case. Disinfecting and disinfectants.

Details of Nursing.—The Nurse: regulation of visitors; management of nurse's own health; washing and dressing patients; bed making; changing sheets; lifting helpless patients; sick diet; administration of food, medicines, and stimulants.

[illegible] bandage and its application. Observation of the sick; [illegible]: skin; appetite: vomiting; cough; ex- [illegible] taking: baths:

SET B. (DETAILED SYLLABUSES.)

LIFE AND DUTIES OF THE CITIZEN.

"It is our business carefully to cultivate in our minds, to rea. to the most perfect vigour and maturity, every sort of generous and honest feeling that belongs to our nature. To bring the dispositions that are lovely in private life into the service and conduct of the commonwealth: so to be patriots as not to forget we are gentlemen. . . . . Public life is a situation of power and energy; he trespasses against his duty who sleeps upon his watch, as well as he that goes over to the enemy."—Burke's *Thoughts on the Cause of the Present Discontents.*

[This Syllabus touches only on certain limited aspects of the public life of the citizen. Various important considerations are therefore omitted which teachers will no doubt discuss in dealing with the subject.]

The subject as here set out will be found difficult to teach, except to those older scholars who are in the habit of reading and thinking intelligently about public affairs. For the instruction of such students the general outline here given may be of service to teachers, though it covers more ground than can be dealt with even in two or three courses. The teacher will select that part which is most appropriate it the circumstances and needs of the school and the locality. For younger scholars a much simpler form of syllabus should be prepared from which the more technical treatment of the machinery of Local and Central Government should be omitted.

The object of the teacher should be to proceed from the known and familiar, such as the policeman, the rate collector, the board of guardians, and the town council, to the history of and reasons for our local and national institutions and our responsibilities in connexion with them.

[Good illustrations and diagrams and pictures will be of great service on teaching this subject.]

INTRODUCTORY.

What the citizen should aim at in the interest of his country.

Public duties accompany all forms of work in life, whatever the occupation or profession.

...nal interest alone is not enough.

... benefits from a well-ordered community. The com-
... benefit in its turn from the efforts of the individual
...uld be requited by "each for all."

The reasons for attachment to our country and for a sense of duty towards our fellow citizens are similar to those for love of home and family. Loyalty to one's own village or town should lead to a larger patriotism. Those who are growing up into citizenship should realise their debt to the men and women who have served the nation generously and wisely in the past, and their own duty to their country in the present. Self interest and class interest should be subordinate to general and national interests.

The Nation and the State.—What they mean. Difference between Representative Government and Despotic Government. Responsibilities involved in representative government.

I.—Representative Government.

What representative institutions mean. The co-operation of the people in the work of government. The power of the majority; its limits. The force of public opinion. Need of public spirit and intelligence for good government.

The machinery of government is partly local, partly central.

A.—Local Government.

Local Government Districts, Small and Large. Institutions of Local Self Government.

1. **The Village and the Parish.**
   The Parish Meeting and the Parish Council. The Choosing of Parish Councillors and District Councillors, &c.
2. **School Districts.** School Boards, School Managers, and School Attendance Committees.
3. **The Poor Law Union.** Boards of Guardians.
4. **Districts under District Councils, Boroughs, and Counties,** Rural and Urban District Councils, Town Councils, and County Councils. The Choosing of Mayors, Aldermen, and Councillors.

Composition and methods of election of bodies above mentioned.

Work and Powers of these Bodies as regards:

1. **Rating and Expenditure.**—The rate collector. Purposes for which money is spent. Difference between rating and taxation.
2. **Health.**—Sanitary condition of houses; drainage, baths and wash-houses; gas; water; purification of rivers. Hospitals; sick nursing. Sanitary and medical officers.

3. **Education.**—Day and Evening Schools. Provision of schools and attendance at school. School attendance officers. Free libraries. Picture galleries and museums. Technical education.

4. **The Destitute Poor.**—The relieving officer. Outdoor and indoor relief. The workhouse.

5. **Roads, Streets, Buildings, and Land.**—Paving and lighting of streets. Public parks and recreation grounds. Town halls and municipal buildings. What goes on inside them. Purchase of land for improvements and public purposes. Allotments and small holdings.

6. **Police and Justice.**

The policeman, his powers and duties. The magistrate, how appointed; his powers and duties. Petty sessions and quarter sessions. Public houses and licensing.

The local representative bodies have in most cases certain responsibilities to or dealings with the Central Government (*see* B iii. Executive Government).

B.—Central Government.

i. The Crown and the two Houses of Parliament.

(1.) **The Crown.**—Its constitutional position and powers.

(2.) **House of Lords.**

(*a.*) Composition.

(*b.*) Powers.

(3.) **House of Commons.**

(*a.*) Composition. How members of Parliament are elected. The franchise and the ballot.

(*b.*) Powers.

(4.) **Working of the Parliamentary System.**—Taxation, legislation, administration. Party Government. Ministry and Cabinet—their joint responsibility. Ministry and Opposition. Majorities and minorities. Their powers. How a Bill becomes an Act of Parliament.

ii. The Judicial System.

(1.) **Justice.**

The Lord Chancellor. Judges. Magistrates. Coroners. How appointed.

(2.) **Courts of Law.**

Civil and Criminal.

Petty sessions, quarter sessions, county courts, assizes, High Court, Court of Appeal, House of Lords. Privy Council.

Juries and their relation to Courts of Law.

iii. Executive Government.

The duty of carrying into effect many of the laws, and the decisions of Parliament from time to time, is entrusted to various public departments, the most important of which are presided over by responsible Ministers of the Crown.

The Work and Powers of the Executive Government.

(1.) In connection with the work of representative Local Bodies in matters of Education, Health, and the Destitute Poor. **(Board of Education and Local Government Board.)**

(2.) In matters of Trade, Commerce, Agriculture, Post Offices, Telegraphs and Savings Banks. **(Board of Trade, Board of Agriculture, Post Office.)**

(3.) In matters of Labour (*see* under III.). **(Home Office, Board of Trade.)**

(4.) In matters of Justice. Prisons and Police. **(Home Office.)**

(5.) In connection with Scotland and Ireland. **(Scotch Office and Irish Office.)**

(6.) In connection with the Colonies, India, and Foreign Countries (*see* II. The Empire). **(Colonial Office, India Office, Foreign Office.)**

(7.) In connection with the Army and Navy. **(War Office, Admiralty.)**

The Army; the Army reserve, militia, yeomanry, and volunteers. The Navy; naval reserve; coastguards. Duties and responsibilities of the soldiers and sailors of the country by land and sea.

The evils of war. Efforts that have been made to avert it by arbitration.

(8.) In matters of Taxation and Finance. **(The Treasury.)**

The country's yearly bill. What we pay for. How the money is got. Direct and indirect taxation.

C. Duties of Citizens in relation [illegible] and Central Government.

1. Ri[illegible]

2. **Rates and Taxes,** and what we get in return for them. Reasons for willingness to contribute to common purposes in well administered countries. Illustrations of gain to the community from improved conditions of life and health as a result of rates and taxes well spent.

3. **Public Health.**—Attention to sanitary matters at home, cleanliness, and ventilation. Isolation and disinfection in illness; temperance and temperate habits; duty to neighbours as well as home and family. Healthiness of a district; its value to the community. Public parks, gardens, and open spaces. Duty of making them beautiful and taking good care of them.

4. **Education.**—Duty of parents. To enforce regularity of attendance, to co-operate with the teacher in regard to conduct of scholars, to home lessons, and the care and use of books.

Duty of scholars. To make full use of the advantages of the school, and thus fit themselves to become capable and useful citizens.

Influence of school on character as well as on intelligence. Waste of force and money through leaving school too early. Technical education, its value for the worker, Higher education and the Universities. School and college only the beginning of the citizen's education.

5. **Provision for the Poor.**—Care of poor children and the sick and aged poor. Consideration of the causes of Pauperism, and how to diminish it. Importance of self-dependence and habits of providence.

6. **Need of Order and Respect for Law.**—The citizen's home and protection. Respect for the persons, opinions, property, and reputation of others. Discouragement of fraud in all relations of life and business. Support of the law and encouragement by example of peaceable behaviour by all citizens. Examples of what the law demands: (*a.*) Registration of births, deaths, and marriages. (*b.*) Notification of infectious diseases. (*c.*) Prevention of cruelty to children and to animals.

7. **Public Spirit and Public Opinion.**—Force of public opinion, need of honesty and intelligence. Freedom of speech and writing. Uses of public meetings; how they should be conducted. Watchfulness over public bodies. Services of the public press in these matters. Active co-operation of the whole body of the people essential to good government and freedom. Willingness of capable persons to serve in a representative capacity on public bodies of great importance.

II.—The Empire.

Ireland. "Greater Britain."—The Colonies.

ı Colonies and dependencies. Self-governing
n Colonies. Protectorates. India and its

Imperial coinage and Imperial postage.

Appointment of Governors General, and Governors.

Obligation to cultivate knowledge about our brethren "across the sea." Native Races within the Empire, and our duties to them.

Extension of friendly feeling, and of courtesy and fair dealing towards foreign nations. Appointment of Ambassadors, Envoys, and Consuls.

III.—Industrial and Social Life and Duties.

Selection for boys or girls of work in life. Loss to the nation when they are set to uncongenial labour. Corresponding gain of "tools to the man who can use them."

What constitutes national wealth. Every capable and industrious and self-respecting citizen should add to the wealth of the community. Relation of skill and knowledge (*a*) to personal well-being and happiness; (*b*) to industrial success; (*c*) to power of public usefulness.

The great industries of the country, their growth and development.

Changes caused by the use of machinery.

Associations of Workers:—

1. Trade unions, their history and work. Labour disputes and strikes. Arbitration and conciliation.
2. Working men's co-operative societies; their work in distribution and production.
3. Friendly societies. Training in habits of industry; thrift and self-help.

Value of the work of voluntary associations in the education of the adult citizen.

The State and Labour.—Factory Acts; Mines Acts; Women's and Children's labour. Dangerous employments. Health and safety of the worker.

Information as to condition of workers. Labour Department of Board of Trade.

The Government and Municipalities as employers of labour, Dockyards, Arsenals, and public works.

The services rendered by retail shopkeepers, merchants, manufacturers, and other persons engaged in distribution and production.

The importance to the nation of effective, honest and intelligent management of all forms of business and industry.

The disasters which result from mismanagement or fraud.

The duty of the community to sympathise with every reasonable effort the workers to improve their condition, and develop their intelligence. at which injures their efficiency or lessens their hopefulness leads to tional loss, and to the maintenance or increase of poverty and ıorance. A healthy and skilful body of workers, upright in character d self-reliant, is a source of strength to the country.

Faithful discharge of homelier duties of life is the best preparation : their discharge in city and nation. Civic duty begins in the life of e family ; expands with occupation in trade, business, and profession.

In earning their livelihood men and women also serve their fellow izens and their country. Membership of self-governing societies is ıong the best means of civic education.

As intelligence, honour, and virtue are essential to the welfare of the nily, so is patriotism necessary to national and social life. We have recognise that our public responsibilities are duties as much as per- al and family obligations. We have no right to expect just legis- ion or impartial administration unless we perform with intelligence se public duties which devolve upon all. If we suffer injustice in nexion with public affairs, we have little right to complain unless have done our own duty.

COMMERCIAL CORRESPONDENCE AND OFFICE ROUTINE.

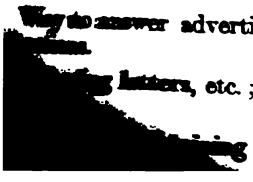
In the following scheme the First Year's Course is planned to give ys and girls, on leaving the day school, an intelligent knowledge of e details and minor duties which are expected from them on entering siness life. Pains should be taken to impress on the pupil the rportance of a satisfactory discharge of his duties and the value of bits of obedience, accuracy, promptitude, and dispatch.

The Second Year's Course is intended for Junior Clerks and those ngaged in subordinate positions in offices, warehouses, and other stablishments.

No student should take up this subject until he has a satisfactory rounding in Commercial Arithmetic, more especially in long additions f money, practice, discount, percentage, and mental arithmetic.

First Year's Course.

A.



advertisements and to write letters of application for

, etc. ; press-copying of written and type-written

multiplex copies of letters, documents, and

lding letters ; addressing envelopes · ation and insurance of letters, etc.

postage book, and petty cash book.

Principal postal regulations and rates of postage—Inland letters; colonial letters; foreign letters. Book post: Inland and foreign; newspapers; patterns and samples; parcels; post-cards; express delivery; railway letter post; redirection.

Incoming letters, etc.—Letter and telegram register; filing, pigeon-holing, and docketing letters.

Telegrams—Writing out and sending telegrams.

The telephone—Sending and receiving telephonic messages.

Forwarding goods—Delivery book; consignment notes; use of railway guide; outline of the railway and canal systems of the United Kingdom.

Remitting money through the Post Office—Postal orders; money orders; telegraph money orders; advice notes.

Receipts for money—Receipts of various kinds.

B. First Steps in Business Correspondence.

The essentials of a good business letter—Correctness as to facts, dates, prices, etc.; clearness and conciseness.

The difference between private letters, official letters, and commercial letters, as regards style and arrangement.

The setting out of a letter:—

The heading.

The date.

The address—Where placed; the correct methods of addressing individuals taking their position, character, and status into consideration; also of addressing Government Departments and firms variously composed.

The commencement—Its position; the differences between the commencement of private and commercial letters.

The body—Arrangement of points in logical order, devoting a paragraph to each.

The ending—Differences as before.

The signing of letters:—

(*a*) Who sign for the firm and how.

(*b*) Who sign as authorised by power of attorney and how; why this authority is given.

(*c*) How employés sign who are not specially authorised by power of attorney.

The letter reference—What this is; where usually given; its use.

Numbering letters—When usual and why done.

Abbreviations usually made use of in correspondence in reference to dates, time, etc.:—ult., inst., prox., a.m., p.m., P.T.O., Regd., P.O. Encl., do., P.S., etc.

The writing of letters relating to business transactions of all kinds, uch as the purchase and sale of goods; the forwarding of invoices, oods, etc.; remitting money by post, cheque, bill of exchange, etc.

Précis writing as used in commerce.

Second Year's Course.

Preparation of inland and foreign invoices, account sales, and ccounts current, and discount and interest calculations on same.

Price lists.

More advanced instruction in railway rates and cable systems. The ses and methods of entry in the principal office and warehouse books, ractice in checking same.

Bank deposit and current accounts; pass books; drafts; cheques nd the crossing and endorsement of same; "not negotiable" cheques; resentment for payment; stopping payment.

Bills of exchange; inland and foreign bills; stamp; date; amount; arties; acceptance; liabilities of parties; currency; days of grace; sance; endorsement; signing bills; case of need; bills sent for cceptance; sets and copies of bills; presentment for payment; dis- ionour; discounting bills; interest; advantages of bills of exchange; ow money is remitted by bills of exchange; accommodation bills; romissory notes; I O U's; council bills; telegraphic transfers; letters f credit.

The markets, and methods of buying and selling goods; how to ead the market reports in the daily newspaper.

The shipment of merchandise, and the forms used in connection herewith, as charter parties, bills of lading and letters of hypothecation.

Business correspondence of a more advanced character; the writing f business circulars, pamphlets and advertisements, and hints as to he compilation of catalogues; modern methods of illustration, with pproximate cost.

How to correct printers' errors and proofs, and the routine of getting matter printed.

The routine of obtaining payment through the medium of the County Court, and from a person's estate, when he has become bankrupt.

Fire, life, fidelity, employer's liability, accident, plate glass insurance, nd other forms of insurance of value to, and made use of by, business men.

VOCAL MUSIC.

(i.) Staff Notation.

Grade I.—Tune.—The Staff and the alphabetical names of lines and spaces in the treble clef. [Male pupils should also be taught the bass clef.] The scales of C, F, and G major. Memorising and pointing simple tunes on the staff. Exercises in leaping from note to note of the scales named.

Time.—The relative values of breves, semibreves, crotchets, and quavers. Semibreve, minim, and crotchet rests. Dotted minims and dotted crotchets. Simple rhythmic exercises combining the foregoing. The Time signatures $\frac{3}{4}$, $\frac{4}{4}$, $\frac{3}{2}$, and $\frac{4}{2}$.

N.B.—Although it is an advantage to study tune and time separately, they should be combined at every stage.

Ear Training.—Imitation (without naming) of simple phrases. The naming of the order in which the tones of a key chord are sung.

Songs and Pieces.—Unison songs with or without accompaniment. Part songs of a simple character where possible. Rounds. The music and the words should be carefully chosen with a view to improve taste, without being dull and uninteresting.

Voice Training.—Attention should be given constantly to exercises in breathing and in the production of good tone. Bad tone in the monotoning of time exercises should not be allowed.

Grade II.—Tune.—The scales of all the major keys, but particularly those most used in vocal music, viz., C, F, B flat, E flat, A flat, G, D, A and E. The sharpened 4th and the flattened 7th. Diatonic intervals.

Time.—All the most used time signatures, but particularly six-eight time. Dotted quavers and quaver rests. Semiquavers. Tied notes.

N.B.—Exercises combining the above time and tune should be studied. It must not be expected that such exercises can be performed at first sight at this stage, but they should be understood when learnt.

Ear Training.—Exercises on the Doh chord and on simple phrases moving stepwise.

Songs and Pieces.—These should be chosen to clearly and pleasantly illustrate the tune and time facts detailed above. The use of part music is desirable.

Voice Training.—Exercises designed to promote good full tone, and to give fluency. Care should be taken to ascertain the vocal capacity of pupils in order that no voices may be strained.

Grade III.—Tune.—The most used minor scales, viz., A, D, G, C, F, E, B, and F sharp minor. Common accidentals and easy change of key. Intervals, diatonic, and chromatic.

Time.—Triplets. Rhythms combining various beat divisions in succession.

Time and Tune.—Studies combining the above time and tune.

Ear Training.—The naming of groups of scale tones in stepwise order, and for the quicker pupils, the naming of groups of scale tones in any order, the keynote being sounded.

Pieces.—These should be well adapted to interest the class, and very endeavour should be made to secure tasteful execution.

Voice Training.—Same as for Grade II.

(ii.) Tonic Sol-fa Notation.

Grade I.—Tune.—The major scale. The mental effects of the various tones and their association with the sol-fa syllables. Octaves and octave marks. The hand signs for scale tones, and the use of the modulator. The memorizing and pointing of simple tunes.

Time.—Pulse accent, and two-pulse, three-pulse, and four-pulse measure. Whole-pulse tones and continuations, half-pulse tones and continuations, quarter pulse tones, and whole-pulse rests.

N.B.—Although it is an advantage to study tune and time separately, they should be combined at every stage.

Ear Training.—The imitation (without sol-faing) of simple phrases. The naming of the order in which the tones of the Doh chord are sung.

Songs and Pieces.—(Same as in Staff Notation, Grade I.)

Voice Training.—(Same as in Staff Notation, Grade I.)

Grade II.—Tune.—The sharpened 4th and the flattened 7th. Changes of key of one remove pointed on the modulator. Bridge notes and simple changes of key written or printed. Singing to "laa."

Time.—Simple rhythms in six-pulse measure. The divisions of pulses named by the time names TAAtefe tafaTAI and TAAfe SAA TAI and TAA SAI. [The use of time names is not obligatory.]

N.B.—Exercises combining the above time and tune should be studied. It must not be expected that such exercises can be performed at first sight at this stage, but they should be understood when learnt.

Ear Training, Songs and Pieces, Voice Training.—(Same as in Staff Notation, Grade II.)

Grade III.—(*Leading to Staff Notation.*)

Tune.—The minor chord and the minor scale. The names and commonest uses of chromatic tones.

Time.—Triplets. Rhythms combining various divisions of a pulse in succession.

Time and Tune.—Studies combining the above time and tune.

Ear Training, Pieces, Voice Training.—(Same as in Staff Notation, Grade III.)

Staff Notation.—The Staff and the alphabetical names of the lines and spaces in the treble-clef. [Male pupils should also be taught the bass clef.]

The signatures of keys and the rules for finding keynotes from a given signature.

Singing from the teacher's pointing on a staff.

The most used time signatures, and the value of notes from the breve to the semiquaver.

The signs for rests. Dotted minims, dotted crotchets, and dotted quavers.

SYLLABUS OF A COURSE OF INSTRUCTION IN ENGLISH HISTORY.

Advanced Syllabus.

The instruction should be general, and not too detailed in character. Its object should be to show the great movements of the period chosen, their causes and effects. The due sequence of events should be made clear, so that their logical results may be made evident. Excessive attention to detail and undue insistence on dates should be avoided.

Specimen Scheme.—1603—1689.

I. The condition of England in 1603.—James I's. position and the political, religious, and constitutional problems to be solved. The attempt to solve the questions of religious toleration, and parliamentary control of the executive—the central point of the history of the century. England was divided on both points.

II. The beginning of the struggle and the course of the struggle involves the chief men, and their actions; Bacon and Coke, and their views of the relations of King and Parliament. Cecil and Buckingham; their attitude towards European States, and especially towards the 30 years' War.

Laud and the Puritans. Strong religious feeling. Scotch Presbyterians and Charles I. The political opposition to Charles I.'s policy. Eliot. Hampden. Pym. Strafford and his policy of "Thorough" Irish Rule.

Growth of opposition to Charles I. in Scotland and England. Hampden, Pym, and the Long Parliament.

III. The Civil War.—Division of England. The War in Ireland and Scotland. Cause of Charles' failure. Cromwell and the Independents.

IV. Cromwell in Ireland and Scotland. His policy at Home and Abroad. Milton and Puritanism. Monk and the Restoration. The causes that led to it.

V. Royalist Reaction, 1660—1688. Clarendon and the Restoration policy. Reaction against Puritanism. The "Clarendon Code."

Shaftesbury—The struggle for Parliamentary control of the Executive. Danby—The religious question raised by the Popish Plot. The foreign policy of Charles II. The struggle with the Dutch for commercial superiority. Royalist Reaction after 1681. The peaceful accession of James II. Rebellions of Argyll and Monmouth. James' alienation of his subjects—his religious and constitutional policy. His rule in Ireland and Scotland. His alienation of Foreign Powers.

VI. Opposition of England to Stuart Rule. Landing of William, and flight of James II. Causes of the Revolution. The settlement—its results, and how far it solved the problems of James I.'s time. The condition of England, Scotland, and Ireland. Their relations with European States.

ELEMENTS OF ECONOMICS.

Advanced Syllabus.

1. The Methods of economic study.
2. The sphere of economic study; population and its industrial divisions; relations of different trades.
3. The State in relation to labour and trade.
4. Assumptions of Economic Science; the market; definition of value, wealth, capital.
5. Production; division of labour; function of capital; increasing and diminishing returns; normal and market values.
6. Distribution; wages, profits, rents; relations of employers and employed.

MERCANTILE LAW.

Elementary Course.

A. Contract.

(*a*). Elements of a valid contract.

(*b*). Offer and Acceptance. Contract by letter through the Post.

(*c*). Necessity of Form or Consideration.

(*d*). Agreements the law requires to be (1) written (2) under seal.

(*e*). Rules relating to the doctrine of Consideration.

(*f*). Capacity of Parties—(1) Infants (2) Married Women (3) Corporations (4) Lunatics and Drunkards.

(*g*). Flaws in Contract—(1) Mistake (2) Misrepresentation (3) Fraud (4) Undue Influence (5) Duress.

(*h*). Legality of Object—Agreements in Restraint of Trade—Elementary knowledge of the view the law takes of Wagers—Distinction between "Differences" and *bonâ fide* purchase of Stock.

(*i*). Assignment and Discharge—Breach.

B. Negotiable Instruments.

(*a*). Features of Negotiability—distinction between Transferability and Negotiability.

Elementary knowledge of—

(*b*). Policies of Insurance—Marine, Fire, Life.

(*c*). Bills of Exchange—Cheques—Promissory Notes.

(*d*). Charter Party—Bills of Lading—Dock Warrants.

C. Agency.

(*a*). General principles underlying Agency.

(*b*). Rights and Liabilities of Principal and Agent (1) *inter se* (2) to third parties.

(*c*). Legal effect of not naming or not disclosing a principal.

(*d*). Ratification.

D. Partnership. Partnership Act, 1890.

(*a*). Usual subject matter of Articles of Partnership.

(*b*). The view the law takes of Profit-sharing.

(*c*). Liability of Partners for acts of Co-partners arising (1) *ex contractu* (2) *ex delicto.*

(*d*). Novation—Holding out.

(*e*). Relationship of Partners *inter se.*

(*f*). Dissolution—(1) voluntary (2) by order of Court.

E. Suretyship and Guarantee.

(*a*). Statute of Frauds—sect. 4.

(*b*). Rights and Liabilities of Surety.

(*c*). Discharge of Surety.

Text Book.

(1) Munro's Commercial Law.
(Macmillan & Co.)

or (2) Pitman's Commercial Law.
(Sir Isaac Pitman & Sons, Ltd.)

Advanced Course.

A. Contract.

(Application of underlying principles to special contracts).

(*a*). Sales of Goods—Act of 1893—Factors Act, 1889.

(*b*). Stock Exchange Contracts.—Legal relations between Jobber, Broker, and Client.

(*c*). Agency. Rights and Liabilities of certain commercial agents. (1) Broker (2) Factor (3) Commission agent (4) Auctioneer (5) Banker (6) Del Credere agent.

(*d*). Insurance.—Uberrimae Fidei—Insurable Interest—Transferability—Special knowledge of clauses in Marine Policies—Average.

(*e*). Bills of Exchange and Cheques.—Their use in commercial dealings—Acceptance—Indorsement—Crossing—Bills of Exchange Act, 1882.

(*f*). Affreightment.—Charter Party—Bills of Lading.

(*g*). Carriage.—Rights and Liabilities of Common Carrier.

. **Pawn, Lien, Mortgage** (of Personal Property).

(*a*). Pawn.—Pawnbrokers Act, 1872.

(*b*). Lien.—Possessory, Maritime, Equitable—Power of Sale.

(*c*). Mortgage—(1) Bills of Sale—Object of the Acts 1878 and 1882—Absolute and Condition Bills—Registration—Seizure of Goods (2) Bottomry Bond—Respondentia.

Bankruptcy.

(*a*). Outline of proceedings from Act of Bankruptcy to Discharge.

(*b*). Board of Trade's supervision.

(*c*). Rights and Duties of (1) Official Receiver (2) Committee of Inspection (3) Trustee.

(*d*). Property divisible and not divisible.

. **Companies.** Acts 1862 to 1900.

(*a*). Kinds—Liability of Shareholders.

(*b*). Memorandum of Association—Articles of Association.

(*c*). Registration—Allotment—Commencement of Business.

(*d*). Winding up—Voluntary, Compulsory, Supervision of Court.

(*e*). Promoters—Directors—Prospectus—Kinds of shares.

(*f*). Improvements introduced by the Act of 1900—Ultra Vires.

. **History of Commercial Law.**

(*a*). Growth of Lex Mercatoria, with special reference to the origin of negotiable instruments.

(*b*). Growth of the doctrines of Consideration and the Separate Estate of Married Women.

(*c*). History of Wagering Contracts and Insurance.

(*d*). History of the Courts—Common Law and Equity contrasted—The Judicature Act—Present constitution of Courts.

. **Procedure.** (Minute knowledge not required.)

(*a*). Jurisdiction of the different divisions of the High Court of Justice, the Courts of Appeal and County Courts.

(*b*). Actions in the High Court.

. **Arbitration and Award.**—Act 1889

ext Book.—Steven's Mercantile Law.
(Butterworth & Co.)

MODERN LANGUAGES.

Elementary Syllabuses.

1. Grammatical rules; easy phrases and sentences, with special reference to conversation; translation of an easy reading book; simple continuous composition.

2. Elements of phonetics; use of a simple reading book and vocabulary; practice in conversation based on the reading book; elementary grammar as deduced from the reading book; writing from dictation; reproduction from memory of phrases or sentences.

3. Practice in conversation by means of diagrams or pictures (such as those prepared by Holzel); correction and explanation of grammatical errors made by students; simple composition.

Advanced Syllabuses.

1. Study of a selected book; detailed comparison of English and foreign idioms, and modes of expression; discussion of words and phrases having slight differences of meaning; continuous composition in the foreign language; study of phonetics.

2. Commercial correspondence; syntax and construction of the sentence; comparison of English and foreign commercial and legal terms; writing from dictation; practice in translation.

Modern (including Oriental) Languages.

Translation from the foreign language into English, with grammatical questions.

Translation from English into the foreign language, or a short essay in the foreign language.

Questions on technical terms of commerce—translation of an English commercial letter into the foreign language, or composition of a commercial letter in the foreign language from notes.

Writing from dictation in the foreign language.

The candidates' ability to express themselves with ease in a colloquial manner should be tested by frequent conversation in the foreign language.

In German the students should be required to obtain a knowledge of German handwriting.

SYLLABUS FOR ELEMENTARY MODELLING FROM THE CAST.

Work in this subject consists of modelling on a different size from that of the original from casts of portions of the human figure, such as eyes, noses, mouths, ears, hands, feet, &c., and from such examples as :

Rosette from the Capitol, Rome (No. 344).
Another ditto (No. 345).
Gothic Boss, Oak leaves (No. 485).
Foliage from Notre Dame (Nos. 2536 and 2754).
Apples (Nos. 2110, 2450, 2451).
Plums (No. 2115).
Pears (No. 2465).
Casts of fruit and foliage from Nature of a similar character.
Portions of Spandril from Stone Church, Kent.
„ „ the Roman Scroll.
The bolder portions of the Trajan Scroll.
Portions of Early English Ornament of a simple bold character ; or casts similar to any of the above.

The above reference Nos. are quoted from Messrs. Brucciani's List of Casts.

MANUAL INSTRUCTION IN WOOD.

(1.) Woodwork.

All lessons in woodwork should be associated with drawing. Each member of the class should, as a rule, make a measured working drawing (plan and elevation or isometric view) of each exercise before proceeding to the work at the bench, and must then work as far as possible from his own drawing, not from a diagram or model, which may only be used so far as necessary to elucidate the drawing. The pupils should be practised in orthographic and isometric or conventional representations of simple constructions ; these should be to scale and dimensioned, but an isometric scale need not be used. Drawing to scale from sketches on the black-board is a good exercise, but students should not, except in the earliest lessons, be allowed to copy any drawing exactly as it is placed before them ; they should generally be required to transpose from orthographic into isometric projection or *vice versâ*, and to draw additional views frequently. The pupils may also make dimensioned freehand sketches (plans, elevations, &c.) of the objects they are about to make, from good models before proceeding to make their own finished working drawing. Drawing-board, T-square, and set squares should be used. The aim of the teacher, in all the exercises, should be to secure accuracy rather than quickness of work.

In connection with their practical exercises the pupils should receive object-lessons on the nature of the different kinds of timber commonly used, and on the principles underlying the construction of the simpler tools.

The lessons should comprise such subjects as the following :—

1. Timber.—Its nature, growth, description, qualities, seasoning, uses, &c. Countries and ports from which we receive our supplies, the forms in which it is brought into the market.

Description of the more common kinds of woods and purposes for which they are best adapted.

2. Tools.—Their names, proper uses, correct handling, principles of construction, and the modes of hardening, sharpening, and using them.

The varieties and uses of the various accessories required in construction, such as nails, screws, glue.

The bench work should take the form of a series of carefully graduated exercises, each successive exercise introducing a new tool or a new mode of using one with which the class are already acquainted. The common tendency to allow the work to take the form of amateur "Carpentry," and that too often of a rough character, should be carefully guarded against. It should always be remembered that the object of the instruction is to train the hand and eye by accurate measurement and by the use of tools, and to impart a knowledge of the principles of simple construction; also that a high degree of skill and rapidity of execution, which are essential to the artisan, and are generally obtained by the frequent repetition of the same exercise, are not to be aimed at. The production of a large number of articles should, similarly, not be made an object of chief concern, especially where this would involve the frequent repetition of the same exercise, or roughness of finish.

The exercises should be so selected as to give variety, and should involve practice in the varied use of different tools and in different methods of construction.

The pupils may be exercised at first in sawing out from a plank pieces of wood of such dimensions as may be conveniently used in future exercises, the pieces so sawn to be cut across in suitable lengths and planed true to required sizes.

The exercises should include making models of the ordinary carpentry joints, such as a simple cross-halving joint; a dovetail halving joint, a mortise and tenon joint; a slip tenon and simple bridle joint. These should be followed by exercises in making simple frames having three or more joints.

Subsequently the pupils may also well be exercised in making models of some useful object, such as a box with dovetail joint, a knife cleaning box, a corner bracket.

With pupils who have made some progress, exercises in hard wood might be practised, such as making a mitre box; a T square 18 inches long; a wooden try square 12 inches long.

For most of the exercises, American yellow pine, or best yellow deal, may be used. For the hard wood exercises, American bass wood, beech or pear wood.

Scheme of Instruction.

First Year's Course.

Exercises in Joint Work.—Housing joint, cross halving joint, T halving joint, notched T-joint, notched cross joint.

Models.—Window wedge, plant label, square prism, square flower stick, key label, flat ruler, string winder, round ruler, flower-pot cross.

Tools used.—Rip and tenon saws, jack and smoothing planes, firmer chisel, compass, rule, gauge, hammer, brace and bit, try square.

Second Year's Course.

Exercises in Joint Work.—Mortise and tenon joint, bridle joint, tongue and groove joint.

Models.—Bench hook, pen tray, flower pot stand, flat ruler, nailed box, finger plate, bracket, set squares.

New tools introduced.—Rebate plane, trying plane, mortise gauge, mitre square gauge, nails and screws, glue.

Third Year's Course.

Exercises in Joint Work.—Cogging joint, mortise bridle joint, bloique halving joints, Tredgold's notched halving joints. Common box dove-tailing.

Models.—T square, try square, towel roller and rests, drawing board, soap-box, scoop, mirror frame, knife box, organ pipe and other examples of science apparatus.

New Tools.—Spokeshave, bevel, dovetail saw, cutting gauge.

(2.) Wood-carving.

First Course.

Evening class meeting, say two hours, twice a week :—

Practice of simple channel cuts with gouge and chisel.

Chip-carving, indenting, and stamping simple patterns.

Second Course.

Practice in tracing from designs; outlining simple forms of leaves and ornament with chisel, gouge, or parting tool.

Carving flat patterns with very little modelling.

Third Course.

For class meeting three or four nights a weeks :—

Drawing, tracing.

Modelling in clay, but only roughly, so as to obtain an idea of form and mass.

Carved studies in pine, such as leaves, fruit, etc.

Carving patterns in low relief, bold relief, and high relief.

Carving in the round.

MANUAL INSTRUCTION IN METAL.

Instruction in metal work in the Evening Continuation School may consist either—

(i.) Of *elementary metal work*, such as chipping, filing, and shaping metal, either by hand, or in the lathe, or by the use of machine tools; or

(ii.) Of *metal embossing and chasing*, in which case sheet-metal is either driven back from the face, or hammered out from the back into relief, and finished on the front surface with fine punches and graving tools.

All teaching should be associated with careful drawing, which should be carried out, if possible, to the full size of the work, or if not, should be executed to scale. The drawings should be supervised by the instructor of metal work, and should be neatly inked in, and supplied with figured dimensions. They should, moreover, serve as the working drawings for the subsequent exercises in the workshop. Such drawings should be executed either from sketches and directions given by the teacher on the blackboard, or they should be based on actual measurements made by the students from models or patterns. In all cases the aim of the teacher should be to impress on the class the importance of accuracy, rather than quickness of work.

It will be advisable that the students should receive clear notions of the properties of metals and their alloys, and of the various methods of casting, rolling, drawing, hammering, annealing, tempering, riveting, &c. Also of the special kinds of work for which different metals are adapted—the distinction between cast and wrought iron, steel, copper, brass, bronze, &c., special attention being directed to such metals as are used by the class.

Explanations should be given of the tools in common use and of the best mode of constructing them, handling them, and keeping them in order.

The exercises should be directed, as far as possible, to teach the student the best way of setting out his work, the tools adapted for the purpose and commonly used, and the objects aimed at in the various operations.

Time.—One hour a week in the First and Second Years; two hours a week in Third; more in Fourth (varies).

(1). Scheme of Instruction for Elementary Metal Work.

First Year.

Filing a square of iron; chipping off corners.

Making a try square in steps:—

Filing circular piece of iron and preparing sides for try square.

Drilling holes and countersinking them.

Marking out and cutting out the centre right-angled piece from the sheet.

Riveting together and finishing try square.

Second Year.

Making drills for use.

Marking out, and cutting with chisel from sheet, the two legs for callipers.

Flatting, filing edges and sides to shape.

Cutting out, drilling and turning washers and riveting together.

Various exercises at lathe.

Forging points or spikes, hook, staple, &c.

Making a paper-weight to size by filing, chipping out the bottom, drilling and screwing holes, turning knob out of bar iron, and screwing it.

Third Year.

Making scribing block by filing cube, turning base and upright, forging and filing needle, drilling, tapping, and filing nut, and making washer.

Making tapping key for electrical work, wood base, gun-metal fittings, turned and milled screws, springs, &c.

In forge—welding and brazing.

Fourth Year.

Small mechanisms, such as screw jacks, parallel vices, raising tables, eccentrics, lathe heads, drilling machines, leading screws, stocks and dies, dividing machines, small lathe, surface plates, electro-magnets, dynamos, galvanometers, &c.

The making of these involves screw-cutting, pattern-making, turning, fitting, forging, tool-making.

(2.) Metal Embossing and Chasing.

Moulding thin sheet metal fixed on soft wood. Outlining simple forms with punch and matts; perforating metal in patterns.

Method of obtaining relief by driving back the ground with stamps and punches.

Use of prick wheel for outlining patterns, tracers, and pointed matt.

Repoussé work on pitch.

Working from the back to obtain high relief, use of beaters and punches, use of graver and fine punches for work on the face. Chasing and engraving on metal.

GENERAL RUDIMENTARY SCIENCE.

This course should be thoroughly illustrated by experiment. If a laboratory be available, the simpler experiments should in all cases be made by the student. In the case of adult students, it might be well to repeatedly call attention to the logical methods of proof used.

Solids, liquids, and gases; changes of state; expansion of bodies when heated; use of the thermometer.

Measurements of length, area, and volume, with simple calculations. Weight of bodies; use of the balance; relative weight; the specific gravity bottle; the U tube or Hare's hydrometer. Weight and pressure of the air; the construction and uses of the barometer. Relative weight of hot and cold air. Other physical properties of the air. Constituents of the air; combustion; indestructibility of matter. Respiration; carbonic acid gas. Water in the air; general properties of water; solution; distillation; dew and rain. Composition of water.

Chemical symbols, formulæ and equations should not be taught in this course.

THE CHEMISTRY OF FOOD AND OTHER MATTERS RELATING TO DOMESTIC SCIENCE.

I. Weights and Measures.

Length; metre and its decimal subdivisions; yard, feet and inches.

Area or surface measurement.

Capacity or Volume; cubic decimetre, pint and ounces.

Weight; kilogram and gram; avoirdupois pound and ounces.

Practical Work.—Compare a metre and yard. Construct a cubic decimetre in cardboard and get it reproduced exactly in tin. Determine the weight of water which fills the cubic decimetre. Compare fluid ounces with cubic centimetres. Find out how many grams equal an ounce avoirdupois.

II. Density and Specific Gravity.

Practical Work.—Make and weigh one cubic centimetre or one cubic inch of soap, clay, and lead. Show that brine is denser than fresh water. Place an egg in water then in strong brine and note the difference. Determine the weight of water which a given bottle will hold; repeat the experiment with spirit, brine, or other liquids and compare the results.

III. Heat and Temperature.

Phenomena connected with changes of temperature,

a. Expansion and contraction. Thermometers, convection currents in water and in air. Circulation in hot water apparatus.

b. Changes of state. Ice, water, steam. Liquefaction and evaporation attended by cooling.

c. Conduction. Comparison of metals with wood, stone, glass, cloth. Materials of clothing.

d. Radiation and Absorption. Influence of colour on absorption of heat from sun or a fire. Formation of dew.

e. Chemical change. Action of heat alone on coal, wood, and other organic substances.—See also under IV.

Practical Work.—Show the lenthening by heat of a steel knitting needle fixed at one end and pressing against a lever at the other. Compare the expansion by heat of water and of alcohol respectively in a flask fitted with a long tube, immersed first in ice, then in boiling water. Observe by a Fahrenheit or Centigrade thermometer the fixed temperatures of melting ice and boiling water. Observe the motion of particles of bran in a beaker of water heated by a small flame at the bottom. Show by means of smoke the hot air currents above a flame or red hot poker. Test by a thermometer the air of a room lighted by gas or lamps, at different heights from the floor. Freeze water by blowing air through ether contained in a flask standing in a small pool of water. Mix powdered ice with half its weight of salt, stir vigorously with a spoon till liquid, then plunge into the mixture a test tube full of water which will freeze. Ascertain the temperature of the mixture by means of the thermometer. Show the use of a "kettle holder," and of wood handle to soldering iron. Show that a thermometer exposed to the direct radiation from a fire does not indicate the temperature of the air. Expose black cloth and white to the sun or fire and note difference of temperature. Heat a strip of bright copper over Bunsen flame and observe the changes of colour and ultimate formation of

a black crust. Heat a piece of wood strongly in a dry test tube and note that water and other vapours are evolved and black charcoal left. The charcoal remains unaltered so long as air is not admitted. Observe that if heated in the air it burns away leaving only a small white ash. Incandescence not attended by burning illustrated by the Welsbach mantle and by the carbon filament of a common "incandescent" electric lamp.

IV. Atmospheric Air.

Composition of the air, and especially presence and properties of oxygen, carbon dioxide, and water vapour. Relation of air to combustion and respiration. Removal of carbon dioxide and restoration of oxygen by vegetation. Atmospheric dust and its organic constituents. Action of heat on metals, *e.g.*, copper, iron, lead, in presence of air.

Practical Work.—Show that a lighted candle suspended in a wide mouthed bottle closed by a glass plate is soon extinguished although only partly consumed. Collect air from the lungs by exhaling through a tube the farther end of which dips beneath the end of a jar filled with and inverted in water. A lighted candle let down into this air is extinguished. Show that the air left after burning a candle and air from the lungs contain carbon-dioxide, as indicated by the lime water test. Fill a bottle with ice, cork it, suspend over a saucer, and collect the condensed water. Examine a wet and dry bulb thermometer, and record readings night and morning for a week. At the same time find the loss of weight sustained by a saucerful of water and record both sets of results on squared paper.

V. Water.

Composition of water and methods of demonstrating it. A substance of definite and invariable properties: melting point of ice, temperature of maximum density and boiling point of water (under constant pressure) are fixed points. The variety of natural waters due to dissolved impurities, such as salts of lime, magnesia, soda and organic matters, as well as suspended mud. Hard water and soft water distinguished by the action of soap.

Solution and solubility. Distinction between melting and dissolving. Solubility of common substances. Common substances dissolved in water usually undergo no chemical change, and can be recovered by evaporating off the water. Some substances not soluble in water, such as chalk and iron, may be dissolved in liquids such as vinegar and other acids. In such cases chemical change occurs and the original solid cannot be recovered by evaporating the liquid.

Practical Work.—Determine the degree of solubility of common salt in cold water by adding powdered salt to an ounce or two of water and stirring thoroughly till a portion of the salt remains insoluble. Pour off a portion of the clear liquid into a small evaporating dish, weigh it, and then place the dish in a warm place till the salt is quite dry. Weigh again. Repeat the experiment with boiling water. The result is nearly the same because salt is very little more soluble in hot than in cold water. Try similar experiments with another salt such as nitre. Evaporate equal quantities (say 200 cubic centimetres) of clean rain water and hard spring water in similar glass dishes, and weigh the dry residue in each. Dissolve a small piece of white soap in a mixture of equal quantities of strong spirit of wine and water. Place 50 cubic centimetres of the same waters in two stoppered glass bottles capable of holding several times as much. Add the soap solution drop by drop to the rain water, shaking after the addition of a few drops till the frothy lather appears permanent. Add the same number of drops of soap solution to the other water and shaken no lather will appear, but the water becomes cloudy. Shake up a quantity

of the rain water with a little powdered chalk. If fresh the water will contain sufficient carbonic acid to dissolve some of the chalk; if not, blow air from the lungs by means of a tube into the water for a few minutes Then filter the water through paper and test again with soap. It will now be found to possess a certain degree of hardness.

VI. Fire and Flame.

Solid fuel, coke and charcoal, burn without flame or with very little flame. Flame is produced by ignited gas. Products of combustion, carbon dioxide, water and a residue of mineral matter (ash). Necessity for air; influence of varying amount of air. Smoke and soot. Wasteful action of common grates.

Coal Gas: its manufacture and products of combustion. Poisonous properties of coal gas. Explosions.

Petroleum: its source and composition. Paraffin oils not to be confounded with fatty oils. The latter contain oxygen as well as carbon and hydrogen, and are convertible into soap by boiling with alkali.

Flame: Structure of candle and gas flames. Construction and use of the Bunsen burner and its application in gas stoves. Incandescence to be distinguished from combustion. The Welsbach mantle and ordinary incandescent electric lamps.

Practical Work.—Examine a candle flame and the flame from a Bunsen burner; show that both are cones of ignited gas containing cool gases within. Cut off air from Bunsen and show that luminosity of flame depends upon limitation of supply of air, and its regulation. Show effect of lamp chimney on luminosity of oil or gas flames. Read gas meter before and after burning gas stove for several hours. Calculate cost of gas as fuel.

VII. Properties of some Common Materials.

Practical Work.

Acids, Alkalis, Salts. General properties, including action on vegetable colours, decomposition of carbonates by acids and interaction of acids and alkalis. Action of acids on common metals.

Salt.—Show that it is neutral to litmus, red cabbage, or violet flowers Heat some dry salt in an iron spoon very strongly and show that it undergoes no change of properties.

Washing Soda Crystals.—Test with litmus and red cabbage or violet and show its alkaline character. Heat the crystals in an iron spoon; show that they liquefy, and giving off steam, leave a dry white residue, which, when re-dissolved in water, reproduce an alkaline solution.

Superior power possessed by caustic soda of removing grease. Prepare caustic soda by boiling slaked lime with soda, and with the clear solution boil some dripping. Salt out the soap formed.

Acetic Acid, or Vinegar. Show formation of vinegar from white wine or beer. Show acidity to litmus, etc., and the decomposition of carbonates, such as washing soda or chalk, with effervescence.

Alcohol.—Make in a flask a solution of one part of sugar in about 20 parts of water, add some pressed yeast and place the solution in a warm place. Observe the effervescence and escape of carbon dioxide, and, when this has ceased, the alcoholic flavour and diminished sweetness. Distil and

collect spirit. Show that rectified spirit is neither acid nor alkaline, and boils at a lower temperature than water. Compare the solubility of salt, soda, camphor, resin, etc., in alcohol and water.

FATS AND VEGETABLE OR ANIMAL OILS.—General statement of composition and action of alkalis leading to production of soap and glycerine. Oil is very fusible fat. Oils and fat insoluble in water, but capable of being emulsified when shaken with water containing a little alkali or a mixture of white of egg and water.

EXPERIMENTS.—Tie beef or mutton fat up in a muslin bag, and melt in boiling water to separate the fat from other parts. Show that fat is insoluble in water, that it floats on water, and melts at a temperature below boiling water. Show that oil has very similar properties to melted fat. Add to some milk a large quantity of powdered salt, and let it stand for 24 hours. Show that the fat will separate and come to the surface.

MINERAL OIL, PARAFFIN, PETROLEUM.—Insoluble in water, but not capable of conversion into soap.

SOAP.—A kind of salt always alkaline to test paper. Dissolved in water show that it is curdled (precipitated) by acids and by much common salt.

SUGAR.—Its occurrence in the sugar cane, and also in beetroot. Different kinds of sugar, *e.g.*, the solid part of honey is a sugar which differs from the sugar in the sugar cane; the same found in all sweet fruits, and is called grape sugar. Grape sugar not so sweet nor so soluble as cane sugar.

EXPERIMENT.—Specimens of ordinary white and brown sugar; also sugar candy and barley sugar. Show that its solution is neutral. Heat white sugar, and draw attention to the peculiar odour of the products of decomposition, and show that on further heating it leaves a residue of carbon. Wash honey with spirit, and show that the residue is a kind of sugar, but that it is not so sweet as ordinary sugar, and not so soluble.

STARCH.—Its composition; the parts of plants which most frequently contain it. Starch granules as obtained from wheat, rice, potatoes, arrowroot, etc. Insolubility of starch grains in cold water; the result of boiling starch. Recognition of starch by the iodine test. Alteration of starch by saliva.

EXPERIMENTS.—Specimen of starch; show by the microscope the starch granules of potato, arrowroot, wheat and rice. Demonstrate that starch does not dissolve in cold water, but in boiling water some does dissolve. Show that starch, both solid and in solution, gives a blue colour when iodine is added to it. Treat weak starch solution with very dilute hydrochloric acid, and heat to convert it into substances (gum and sugar) which are soluble in water.

GLUTEN. *The proteid of flour and bread.*—Tie some dough in a piece of muslin and knead it for some time in a basin of water; the starch comes through and will settle to the bottom of the vessel and can be collected and examined. The gluten remains in the bag. Heat some flour in a porcelain dish, first in an oven where it turns brown, and then more strongly over a flame. It blackens and yields a smell unlike that of burnt sugar, but like that of burning feathers. Observe the black mass of carbon left behind. Place a lump of this on a piece of platinum foil and heat till the carbon is burnt off. A small white ash remains.

VIII. METALS.

IRON.—Infusibility in ordinary fire. Cast iron, malleable iron and steel distinguished by mechanical properties. Are capable of rusting in moist air, and becoming covered with scaly oxide when heated to redness. Cleansing of rusty iron by means of lime and soap.

COPPER AND BRASS.—Do not melt in a common fire, but when heated become rapidly coated with a black crust of oxide. Easily attacked by vegetable acids in presence of air.

LEAD.—Readily melts on a hot iron plate. Speedily acted upon by common water, and may dissolve sufficiently to communicate poisonous properties to the water.

SILVER.—Fusibility about the same as copper, but unaltered by heating in air. Blackened by contact with coal gas or smoke, owing to formation of sulphide. Much better conductor of heat than German silver or other cheaper white alloys.

IX. THE HUMAN FRAME.

The chemical elements entering into the composition of the human body. The necessity for supplying these in the form of food. The importance of mixed diet.

Food as a fuel: the maintenance of the body temperature. Function of air in respiration. The kinds of foods which supply the different needs of the body.

Elementary notion of the general functions and structure of the digestive organs. The general character of the changes that food undergoes in digestion.

FOOD STUFFS.—Meaning of the terms *proteid carbohydrate, fat.* Examples of their occurrence in common articles of food.

Flesh.—Composition of lean and fat meat respectively.

Milk and Dairy Produce.—The substances contained in Milk, preserved and condensed milk, cheese, butter; their value as articles of food.

Cereals.—Wheat, rice, cornflower; what they contain.

Fruit and Vegetables.—Difference between the seeds of leguminous plants and the grain of wheat. Potato, chiefly composed of starch. Salts present in succulent vegetables.

PRINCIPAL EFFECTS OF HEAT ON THE CHIEF TYPES OF FOOD STUFFS.—The changes produced in an egg by boiling. The cooking of meat. The cooking of vegetables and flour. Action of heat on starch.

PRACTICAL WORK.—Weigh an egg before and after boiling. Stir up flour, starch or arrowroot with cold water and observe that on standing it settles to the bottom apparently insoluble. Determine with the aid of a thermometer the temperature of water in which starch becomes gelatinised. Study the process of bread making, the use of yeast and of baking powders. Show that the latter, when wetted, evolve a gas which is identical with the gas produced by alcoholic fermentation. Find the percentage of water in meat, bread, raw potato, etc., by weighing out a small quantity in an open dish, and drying at a temperature not exceeding 300°F. Heat a small piece of meat or of egg more strongly in a dry test tube, and show by smell and test-paper the evolution of alkaline vapours containing ammonia. Heat starch and sugar in the same way. Determine the loss of weight on roasting meat.

PRESERVATION OF FOOD.—Putrefaction and decay; tinned foods. Organisms producing decay. The sterilization of food.

Nature of preservatives and tests for the more important, such as boracic acid, salicylic acid, formaline.

The suggestions for practical work are intended to indicate the kind of experiments that are desirable, and not in any way to limit or define what these shall be.

ELEMENTARY RURAL SCIENCE.

1.—The Plant and Soil.

This course is intended for ordinary village lads, the sons of small farmers, labourers and the like, whose education has not extended beyond that provided at the Elementary Schools. The idea is to provide an elementary course on the science of plant life and soil, which will at once interest and instruct the student, and lead up to the intelligent study of Agriculture or Horticulture. The syllabus is not intended to give more than an outline of the course of instruction which is deemed advisable; details being left to the discretion of the teacher. It may be necessary for the teacher to vary the arrangements occasionally, so as to render the teaching appropriate to the season of the year.

Teachers are recommended to let the experiments and observations precede the explanations, and to give the class an opportunity of drawing their own conclusions without suggestion or anticipation. The simplest possible language should be used; it will be found possible to dispense with most of the learned language of text-books. Drawing, and especially drawing to scale, is a great help to the right understanding of the structure of plants and animals. Lecturing, and all forms of instruction in which the class is passive are to be avoided.

Plant Life.

Seeds.—Examine structure of bean, buckwheat, and maize; soak in water, dissect, and examine with lens; point out protective covering, and solid contents united to embryo. *Conditions of Germination.* Plant seeds in sawdust; keep some wet and others dry, some cold and others warm, some in the light and others in the dark; observe the effect of these different conditions on germination. Completely fill a bottle with water, introduce a few seeds and insert the stopper so as to leave no air in the bottle; keep in a favourable temperature, and compare development with similar seeds in air. *Mode of growth.* Which first emerges from the seed-coat, and which grows most rapidly, the stem or root? The solid matter of the seed is at first the only plant food; a young wheat or barley plant has an empty husk on its root. Subsequent growth demands light and soil-food. Grow seeds in pots in full light, shaded, and in darkness.

Roots.—Examine the roots of the various seedlings which have been grown; notice the position of the root hairs at various stages of growth. Watch the development of the secondary roots. Examine the various forms of roots shown by farm crops; the plants having enlarged roots (carrot, turnip, etc.), are those which will grow again the following year. Grow seeds of wheat, barley, and white clover, and watch the development of the root and shoot system. Examine the roots on young shoots of ivy, strawberry runner, the underground stems of couch grass, potato and mint. Fix a seedling of scarlet runner in a closed box or bottle (kept moist by a wet sponge) so that the main root is horizontal; notice how it responds to the pull of gravity.

Leaves.—Their shape designed to expose the largest surface to light and air. Structure of leaf-veins shown in skeleton (rotted) leaves.

Transpiration.—Put leafy shoots in water coloured red with eosin and keep in a warm room in full light for 12 hours. Observe the red in the leaf-veins. Make sections of the stem, and trace the course of the coloured water. If a leaf is constantly receiving water from the soil through root and stem it must also lose water. Take a test tube and a well-fitting cork, split the cork lengthwise, fit the pieces on either side of a straight leaf, like wheat or daffodil, and slip into the test tube. Let the leaf remain on the plant, and note the water collected in the test tube after 24 hours. Take a pot containing a living plant, closely wrap the pot and earth with sheet india-rubber to prevent the escape of water-vapour, and place a glass jar over the pot; observe the condensation of water inside the jar during the day. Take a jam-pot or any other glazed jar, plant in it a young cabbage or sunflower; when established, cover as much of the soil as

possible with tinfoil, weigh the pot and plant after watering, and note the loss of water by next day. Make daily weighings and note how the loss varies with sunshine and warmth. Which surface of the leaf loses water most readily? Press fresh leaves between two slips of glass, and note which slip becomes most moist. Plunge a fresh laurel leaf into a tumbler of boiling water, observe that bubbles of air issue from the under surface only. Examine with a lens the upper and under surface of box and other leaves; the openings for the passage of water vapour and the admission of air are generally found on the under side.

Formation of Starch.—Keep leaves (tropæolum, primrose, marigold, cabbage, etc.), in the dark for 24 hours, then expose some of these to sunlight for several hours. Dip one of each lot successively into boiling water, into methylated spirit till the green colour is removed, and into a weak solution of iodine (colour of sherry); observe the difference due to sunlight. Show by treating thin starch paste, and slices of potato with iodine solution, that the dark blue colour is due to the presence of starch. Fasten corks or letters cut out of tinfoil on the surface of green leaves still attached to the plant; after one or two days remove the leaves, and test as before for the presence of starch. (These leaves may be prepared in summer and preserved in alcohol until wanted.) Expose to sunlight a variegated leaf of geranium or some other plant and treat as before; observe that the starch is formed in the green portion of the leaf only. Show that air is needed for starch formation by exposing darkened leaves to sunshine both in air and under water. Smear the under side of a darkened leaf with vaseline, and expose to light; the closing of the pores prevents the formation of starch

From what substance in the air is starch formed? Fix a darkened leaf in a closed bottle containing a little solution of caustic soda or lime-water and expose to light; no starch is produced. Show wood charcoal, called carbon; how made. Heat starch on an iron spoon—it also yields carbon. Take a few pieces of glowing charcoal on a shovel, which has been strongly heated previously, and then removed from the source of heat. Hold an empty bottle mouth downward over the pieces so as to catch the hot gases coming away. Close the mouth of the bottle with a card, turn over, pour in some lime-water and shake up. Repeat the experiment with starch. Starch contains much carbon. Carbon, when burnt, supplies the air with a gas, carbonic acid, which turns lime-water milky. Show another source of carbonic acid in the air by breathing through a tube into lime-water.

Stems and Buds—Shew the structure of buds in a head of cabbage, and in the buds of horse-chesnut and sycamore, and trace their subsequent development. Structure of a woody stem; pith, heart-wood, sapwood, growing layer, bark. The yearly growth in thickness.

Healing of wounds on trees. How knots arise in timber. Budding and grafting. Formation of roots from cuttings; experiment with willow twigs and fragments of watercress placed in water, and with geranium cuttings placed in soil. From what part of the stem do roots start? Creeping stems, above ground and under ground; strawberry, couch-grass, bindweed. Peculiar forms shown by onion, tulip bulbs, crocus corms, potato. Trace the development of a tulip bulb and a crocus corm from month to month.

Flowers, Fruits and Seeds.—The parts of a flower and their uses. The transference of pollen by wind and insects. Catkins. The parts which develop into fruit. Study of fruits; pods of peas, siliquæ of wallflower, capsules of poppy, nuts of hazel, acorns, apples, gooseberries, plums, raspberries, strawberries, vegetable marrows. Means of dispersal of fruits and seeds.

Review of Plant Life.—Early dependence on food provided by parent. How the plant obtains, stores, and spends its food. Annuals and biennials, bulbs, tubers, perennials.

The Soil.

Soil supplies Plant Food.—What has soil to do for the Plant? Besides supporting it, and supplying water, it supplies certain parts of plant

food. Burn twigs of wood, and dry old leaves, to white ash. The part burned away has been nearly all derived from the air (as carbonic acid and water), the small amount of ash comes from the soil. Plant seedlings in clean washed sand, and in good soil; the sand is a good support and supplies water, but nothing else; note the difference in growth.

How Plants Appropriate Soil Food.—Roots take up water, with this the things dissolved in water. Illustrate solution by experiments with salt, sugar, etc. Take clear water which has passed through a soil and evaporate to dryness in a glass vessel; show the residue left. Acids will dissolve things that water cannot. Try vinegar on chalk. Show that hydrochloric acid can dissolve a small piece of marble. Place a thin bone in dilute hydrochloric acid, in a few days the bone will be soft and transparent, the phosphate of lime having been dissolved. Let the root of a living bean seedling rest on blue litmus paper, and observe the result. Grow some bean seedlings in shallow earth laid upon a slab of well polished marble; after six or eight weeks clear away the earth and observe the corrosion of the marble. Roots thus not only take up the things dissolved in the water of the soil, but themselves dissolve some of the solid matter.

Origin and Composition of Soils.—Show how soils may arise by describing the formation of some soil in the neighbourhood. Take the class if possible to see a section showing soil and subsoil. Soils are made up of coarse and fine materials, resulting from the breaking up and washing of older rocks. If coarse material, then many stones, gravel, coarse sand; if fine material, then very fine sand and clay. Boil soil in water for half an hour, and show how, by stirring up with water and decanting after a minute or two, the fine matter may be separated from the coarse; repeat the treatment till the water comes clear. Treat 1 oz. of a clay, and 1 oz. of a sandy loam in this manner, and compare the results.

Study the characters of sand and clay. Mould small bricks of wet earth, of sand and clay, measure them, then dry; note any alteration in size when dry, also the looseness or hardness of the dried substance.

Take two vessels of zinc, one to two inches in diameter, having a perforated bottom; cover the bottom with blotting paper, place in them 50 grammes (about 2 oz.) of coarse sand and dry powdered clay, pour slowly the same quantity of water (about half the volume of the sand) on to each; observe how much comes through in either case. Take two similar quantities of dry clay, place one lot in the zinc vessel as a coarse powder, the other lot in a mortar, moisten with water, and rub with the pestle to a smooth paste, turn this into the other zinc vessel; now fill up each vessel with water, and note what quantity of water drains through. What do we learn from these experiments as to the behaviour of a clay soil? Mention ordinary classification of soils according to the proportion of clay present, and point out the behaviour of these soils when cultivated by the farmer.

Another ingredient of soil, present generally in small quantities, is chalk or limestone; how may this be recognised? Treat chalk and limestone with an acid; observe what happens. Treat various soils with the same acid, and notice if chalk is present. What are these bubbles of gas? Treat any effervescing soil with acid in a bottle fitted with a bent tube, and conduct the gas into lime-water. Chalk not only gives up carbonic acid when treated with a stronger acid, it also does so when burnt. What are the products of a lime kiln? Chalk and limestone are carbonate of lime. Lime important in soils in many ways. It makes the clay friable. Show boiled clay suspended in water in two vessels, to one add lime-water and note the result.

One plain distinction between surface soil and subsoil. Why is the upper soil darker? The darkest soils are peat, and turf from meadow; why? The dark substance called humus. Being decayed plant substance, it contains carbon and nitrogen. What become of the humus? Is there any connection between humus and the nitre? What soils are rich and poor in humus?

2.—Bee-Keeping.

1. Advantages of Bee-keeping. Usefulness of Bees : (*a*) as producers of food, otherwise wasted. (*b*) As fertilisers, valuable to the farmer or gardener. Districts suitable to the industry.
2. Life-History and Structure of the Bee. The egg, larva, pupa queen, worker, drone. Varieties of the Honey Bee. Construction of the Comb.
3. Bee-keeping Appliances. Straw skeps. Modern appliances :—Bar-frame hive (different forms of it), including description of the various parts of a hive—outside case, brood-chamber, section-crates, etc.
4. Other Modern Appliances (including a description of how to fit some of them up) :—Bar-frames, with wax foundation. Sections, with wax guides. Feeders. Smokers. Honey-extractors. Wax-extractors.
5. Management of Bees. How to quiet bees. Transferring bees from skeps to bar-frame hives. Stocking hives from "condemned bees," *i.e.*, those which would have been destroyed by their owners in taking the honey.
6. Management in Bar-frame Hives. "Spring cleaning" of hives. Artificial swarming. Prevention of swarming. Taking Honey. Queen Rearing. Uniting weak stocks. Feeding and wintering bees. Packing and removing bees.
7. Some Difficulties, and how to overcome them. Robber-bees. Enemies of bees—wax moth, mice, etc. Diseases of bees. How to deal with accidents arising from bees.
8. Preparation of Honey for the Market. Cleaning sections, and glazing where required. Extracting honey. Extracting wax. Sale of honey and wax.

NOTE.—The instruction should be accompanied by as much practical work as possible. *Sections 2 and 8* may be illustrated by diagrams or lantern slides ; *Sections 3, 4 and 9* should be illustrated by practical in-door work, in which the pupils should take a part, including demonstrations of the various appliances and the methods of fitting them up and employing them. *Sections 5, 6 and 7* should be accompanied by out-door work at the bee-hives at the appropriate seasons of the year.

3.—Insect Friends and Enemies.

The characters and general structure of insects, as exhibited by some good sized and common example, such as the Cockroach.

The structure and life-history of a Carabus or Cockchafer, as an example of beetles, and two or three of the following, taking such as happen to be locally plentiful, and treating them more briefly :—Dytiscus or Tiger Beetle, Clickbeetle (and Wire-worm), Turnip flea-beetle, Elm-bark beetle or Pine beetle.

The structure and life-history of some Moth or Butterfly, such as the Tiger moth, or Lackey moth, and more briefly two or three of the following :—Cabbage white butterfly, Tortoise-shell butterfly, Silkworm, Vapourer moth, Codlin moth, Pea-moth.

The structure and life-history of the Hive-bee, the Gooseberry saw-fly or Pine saw-fly, and some common Ichneumon, such as Ophion.

The structure and life-history of the Crane-fly ("Leather Jacket," "Daddy-long-legs,") Blow-fly, the Bot-fly of the horse, and the Warble-fly

The structure and life-history of an Aphis (Rose or Turnip Aphis) and a Scale-insect (Currant-scale, Mussel-scale of Apple-tree or Ash-bark scale)

The method of examining the mouth-parts of insects ; the mouth-parts, wings and transformation as means of distinguishing the orders.

Protective resemblance, mimicry, development from unfertilised eggs and viviparous generation, as exemplified by common British insects.

The part which insects play in the decomposition of dead vegetable and animal matter, in nourishing birds, and in fertilising flowers.

The chief means of combating the the insect-pests of :—

(*a.*) Farm and garden crops.
(*b.*) Fruit-trees.
(*c.*) Forest-trees.
(*d.*) Farm-animals.

4.—Cottage Gardening.

Soils and Situation.—Danger attending certain situations through want of drainage, late Spring or early Autumn frosts.

Preparation of the Land.—Digging, trenching, bastard trenching ; hoeing, raking, and surface cultivations. Drawing drills. The tools required for the above operations, and the care that should be given to them. The importance of keeping the land clean and free from weeds.

Manures.—Time of year and condition in which to apply stable manure : crops to which it is suited. Use of lime and soot. Use of clay, road grit, ashes, leaf mould, &c., to improve certain kinds of soil.

The Arrangement of the garden plot to make the most of the ground, secure a proper succession of crops, and get rid of weeds.

Seeds and their Requirements.—Preparation of the seed bed. Seed sowing in the open ground. Protection of the seed from drought, birds, mice, &c. Thinning out. Seed sowing under glass ; pricking off, hardening, and planting out.

Management of Green Vegetables.—Spring and Summer cabbages, kale and brussels sprouts ; broccoli and cauliflowers. When to sow and transplant. Pests and their treatment—cabbage caterpillar ; flea beetle ; club root.

Spinach, lettuce, and other leafy vegetables. The management of celery—sowing, preparing the trench, manuring, planting out, earthing up, and blanching.

Pod-Bearing Vegetables.—Preparation of soil. Management of Beans—broad, runner, and dwarf French. Peas, early and late sorts, dwarf kinds and those requiring staking.

Potatoes.—Preparing the ground and manure. Preparation of the sets for planting. Early and main-crop sorts to grow. Cultivation. Lifting and storing the crop. The storage of seed potatoes.

Tap-Rooted Vegetables.—Turnips, beet, carrots, and parsnips. Preparation of the ground. Time for sowing. Enemies—Wire worm ; carrot fly, and flea beetle.

Onions.—The seed bed. Transplanting. Ripening the crop. Autumn and Spring varieties. Destruction of the onion fly.

The Vegetable Marrow.—Time to sow and plant out. Requirements for water and manure.

Flowering Plants.—The best annuals ; hardy and half-hardy sorts, and their management. Sweet peas, stocks, asters, as examples. Management of dahlias, carnations, roses in the open and against a wall. Window plants like the pelargonium and fuchsia ; watering and propagation.

5.—Poultry Keeping.

The construction of houses, ventilation, lighting, internal fittings, various systems of housing. Covered and other runs. Coops. Dust-baths. Feeding and drinking utensils. Buying and maintaining Poultry-plant.

General Management.—Eggs wanted for hatching. The broody hen or clucker (indications of broodiness), her nest, her special requirements; various methods of treatment during incubation and when hatching off. Selection of site for the chicken coop. Rearing the chicks, home and foreign methods described and compared. Separation of chickens from the hen and the sexes from one another. Distinctive treatment of growing stock, pullets for winter laying, cockerels for breeding purposes, "green" or "running" stock.

Selection of stock birds, the points indicating health, age, great laying qualities and profitable table birds.

Mating up the breeding pen.

Foods and Feeding.—Methods of feeding appropriate to stock at different ages and wanted for various purposes. Foods commonly used, their properties and the circumstances guiding a successful use of them. Foods to avoid. Some foods which could be more often used with advantage.

Grit and other important details.

Anatomy.—A short description of the alimentary canal and egg producing organs, emphasising the peculiarities in the bird which are instructive as to its management.

Breeds.—The chief breeds of Poultry. Leading points by which they are readily distinguished. Conditions such as soil, climate, etc., which should influence choice of breed. The useful characteristics of various breeds. The abuse of breeding for fancy points only.

The Diseases of Poultry. Insect Pests. Field Vermin.

Management of birds other than the fowl common in the poultry yard: Turkeys, Ducks, Geese.

Marketing.—Storing and preserving eggs. Preparing poultry for Table.

6.—Measuring and Weighing.

Comparison of Measures of Length.—The yard and the metre; inch and the centimetre. The chain. Number of these units in one another. The use of scales. The construction of paper scales for different purposes.

Drawing to Scale.—Measuring and drawing to scale simple objects like the schoolroom cupboard and the master's desk. The principles of projection and intersection in making plans, elevations and sections

dimensions required for area. Calculation of the area by the use of squared paper and by weighing. Calculations of areas—floors,

MACHINES.—The theory of the lever as worked out by simple experiments with a rod marked in inches, some weights, and a small spring balance. Examples of levers—balances, steelyards, etc. Other simple machines—the wheel and axle, the inclined plane, pulleys, toothed wheels. Illustrations from farm implements, etc., of the application of these mechanical devices.

STRUCTURES.—Tension and compression. The triangle the only figure which resists distortion.

Illustrations of this principle in the construction of the ordinary field gate, the king-post, truss, etc. Tie-beams and struts. Beams, their formation and placing with respect to pressure.

DRAINAGE.—Principles of simple levelling to determine outfall and direction. Making a simple level with gas pipe and bottles. The construction of a graduated staff. Amount of fall required by water in streams or pipes of different sizes as shown in actual examples.

THE COURSE MUST BE TAUGHT EXPERIMENTALLY.—The teacher will require a few yard and metre rules, a measuring tape, a surveyor's chain, a few measures—pint, quart, litre; a jar graduated into cubic centimetres or fluid ounces; a balance and weights, also a spring balance, weighing up to twenty pounds.

Each pupil must have a drawing book and a foot rule. All experiments, plans, etc., should be sketched on the blackboard, and drawn out to scale by the pupils in their note books.

SCIENCE APPLIED TO PLUMBING.

Technical Drawing.—The construction and use of scales Simple geometrical exercises. Simple plans, elevations and sections The use of dotted and full lines. Inking in and colouring drawings Dimensioning and finishing off drawings.

Mensuration and Arithmetic.—Vulgar and decimal fractions Cross multiplication and square root. Mensuration of plane, figures and curved surfaces, *e.g.* areas of parallelogram, triangle, circle, sector, etc., with special reference to the cutting out of sheet lead in various forms for covering dormers, gutters, lantern lights, etc. Measurement of volumes, *e.g.*, the volumes of the sphere, right and oblique cylinder prism, cone, and pyramid.

Heat and Electricity.—Distinction between heat and temperature. Effect of heat on solids, liquids, and gases. Cause of frost-burst, and various methods of preventing it. The three modes in which heat is conveyed from place to place. The effect of heat in causing motion in liquids and gases. Ventilation of pipes. Thermometers and thermometric scales. Measurement of the quantity of heat. Relation of quantity of heat applied to rise of temperature in air, water, lead, zinc, and other substances used in plumbers' work. Introduction to Voltaic Electricity.

Solids.—Density of Materials, Calculations of the weight of simple solids and figures made of sheet metal.

Chemistry.—Air, its constituents and weight. Water, its composition; impurities of water; solvent action; hard and soft water. Oxygen, its properties and compounds. Acids and alkalies. Metals, Lead, iron, copper, tin, etc. Alloys, brass, gun-metal, etc., properties, compounds and composition. Solders, their composition and preparation. Fluxes. Lead burning.

INSTRUCTION IN COOKERY AND LAUNDRY WORK.

Courses of Cookery and Laundry Work should include oral instruction, demonstration, and practice. Examples of the courses are given below.

At each Cookery Demonstration a fresh principle of Primary Method should be taught, or in the case of Laundry Work one of the various processes should be taught. At each Practice Class the fresh principle or process should be practised by the scholars, and afterwards any dish or process which they may have a desire to attempt and for which the time allotted for the lesson will permit. It is not advisable for a teacher to attempt to teach more than three different kinds of dishes or methods of Laundry Work at one time during a Practice Class.

COURSES OF COOKERY should include instruction on:—

Baked, boiled, fried, or stewed meat or fish.
Steamed, baked, or boiled puddings.
Cookery of vegetables.
Choice and price of the food used at the classes.
Expenditure of wages on food.
Menus of dinners suitable to the neighbourhood, and price.
Management of coal, gas, or oil stoves.

COOKERY.

Every alternate lesson should be one for practice. Where three lessons are mentioned two should be for practice.

First Course.

1. Making stock, plain soup. Plain buns. (2 lessons.)

2. Beef steak or rabbit pie, pancakes. Pastry making. (2 lessons.)

3. Different ways of cooking meat, choice of meat and price. Savoury stew, grilled chop or steak. Tartlets. (2 lessons.)

4. Scones, tea-cakes. Bread making. (2 lessons.)

5. Puddings. Difference between steaming and boiling puddings. Small Christmas puddings, mincemeat. (2 lessons.)

6. Dinner. Roast meat, Yorkshire pudding, potatoes, green vegetable.

   Fish. Cookery of fish. Fried fish, boiled fish. Raised pork pie.

   Wages and expenditure on food. (4 lessons.)

7. Using up scraps in the larder. Rissoles, patties, fish cakes, fish puddings (2 lessons.)

3. Invalid Cookery. Beef tea (3 methods), mutton broth, steamed fish, semolina pudding, omelet. (2 lessons.)

9. Boiled Pastry. Beef steak or rabbit pudding, cheese pudding, small cakes. Menu of dinners for a week with the price of each. (2 lessons.)

Second Course.

1. Plain Household Dinner. Marketing and care of larder. Good family soup (white, gravy, or kidney), stuffed and rolled steak, fruit tart. (3 lessons.)

2. Dairy produce, choice and food value. Toad in the hole, macaroni, cheese, apple fritters, buttered eggs. (3 lessons.)

3. Meat. Choice of poultry, cookery of vegetables. Roast fowl or rabbit, bread sauce, potato croquettes, cauliflower and sauce. (3 lessons.)

4. Cakes. Various cake mixtures and baking the same. Plain plum cake, sponge cake, small cakes. (3 lessons.)

5. Jam Making. Making marmalade. (3 lessons.)

6. Cold Meat. Frying (wet and dry). Croquettes, hash and mince, kedgeree. (3 lessons.)

7. Puddings. Lemon or orange jelly, marmalade pudding, cheese pudding, macaroni. Clearing plain jellies, food value of gelatine. (2 lessons.)

THE LAUNDRY COURSE should include information on:—

Material used, such as soap, starch, soda, borax, water.
Choice, care, and price of utensils used.
Washing, ironing, and "getting up" of linen, cotton, and flannel garments.

LAUNDRY WORK.

he work in each course should be divided into about 20 lessons, of which about 12 or 13 should be for practice.

First Course.

Preparation necessary for washing day; soap.
Washing white and coloured flannels and stockings. Washing and ironing plain and fancy handkerchiefs.

Rules for drying. How to hang clothes on a line.

Making hot and cold water starch. Washing, starching. Ironing and glossing collars and cuffs.

Hard and soft water. Washing, starching and ironing coloured prints and crewels; a blouse; under-linen; a shirt; table linen.

Utensils used in laundry work.

3. Disinfectants. Removing stains; *e.g.*, tea, coffee, wine, fruit, etc.

Second Course.

1. Various kinds of irons and their uses. Alkalies. Starch, borax, soda, blue, wax, turpentine.

   Washing, starching, and ironing a blouse; a shirt.

   Washing and ironing white and coloured silk and lace, and goffering lace.

2. Disinfectants. Removing stains; *e.g.*, tea, coffee, wine, fruit, etc.

   Washing bath towels, washing and colandering chintz, muslin.

   Melted soap and its uses. Uses of gum water, bran water, alum water, vinegar.

   Children's hats and sun bonnets.

   Paraffin washing.

   Starching and ironing babies' robes or children's frocks or garments trimmed with lace.

SYLLABUS OF A COURSE OF FOUR LESSONS IN GARDENING.

Lecture 1.

Soils and Manures. Description of various soils. How fertility should be maintained. The value of deep culture. Treatment of heavy and light soils. Draining. Digging and trenching. The preparation and uses of farm-yard manure. The value and application of chemical manures. Results of experiments with chemical manures. How plants and crops obtain their food. The value of leaves.

Lecture 2.

How to produce Heavy Crops of Fine Vegetables. Preparing the soil and sowing seed. Right and wrong methods. The importance of thin sowing, and early thinning of seedlings. The arrangement of crops. How to help crops forward in spring. The advantages of frequently stirring the soil. Watering and feeding with liquid manures. Storing.

Lecture 3.

Fruit Culture: Apples, Pears, Plums and Cherries. Selecting suitable sites and soils. Soil preparation. Arrangement of trees. Planting, good and bad methods. Summer treatment. Diseases and insect pests, causes and prevention. Pruning. Budding and grafting. The value of artificial manures in fruit culture. Treatment of old orchards. Gathering and storing fruit. Varieties.

Lecture 4.

Strawberries and Bush Fruit. Time and method of planting. Varieties for various soils. Summer and winter treatment. Suitable manures. Cost of culture. Value of crops.

Bush Fruit: Gooseberries, Currants, Raspberries. Planting and pruning. Summer pruning. Treatment of established bushes. Hints on packing and marketing.

Outdoor Demonstrations may be given in the afternoons (weather permitting); the place of the next Demonstration being announced at each Lecture.

Work to be done in School Gardens.

Vegetable Culture.

Digging and trenching; explaining the advantages of thoroughly working the soil. Methods of treating both heavy and light soils. Proper and improper methods of using tools.

Experiments in applying both dung and chemical manures, to show the effect of the various elements of plant food.

Drawing drills for the reception of seeds. Preparing seed beds. Correct methods of sowing seeds of various descriptions, including at what depth to bury them, and suitable distances apart for the rows.

Raising and transplanting seedlings; importance of thinning early.

Raising plants to form a succession of crops. The value and method of double cropping. Suitable positions for various crops.

Feeding crops during the growing season. Practical lessons in frequently stirring the soil while crops are growing, to cause them to make rapid progress.

How to destroy insect pests.

How to prevent diseases; how to destroy them in their early stages.

Spraying potatoes.

The advantages of maintaining order and cleanliness throughout the season.

Testing the merits of various kinds of vegetables.

When to gather crops for present use, or for storing.

Fruit Culture.

Planting Black and Red Currants, Gooseberries, Raspberries and Strawberries.

Lessons in the style of pruning suitable for each, and in their management throughout the year.

Planting Apples, Pears and Plums. Instruction on their management.

Budding and Grafting.

Destroying insect pests and diseases.

On wet evenings theoretical instruction may be given.

BASKET MAKING.

A. Materials.

Osiers.—Green, brown, buff and white.

The kinds grown include 28 varieties, and experiments are made to determine those which are best adapted to the local soil, and to special requirements. Examples of leaves of the different sorts of osiers are framed for inspection, &c. Measurements, showing the amount of growth in a given time, are tabulated.

Localities suited for **osier** cultivation. They grow in any soil except peat. Characteristics—height 3 inches to 60 feet, rapid growth. Cuttings, wood, bark.

Salicine.—What osiers are.

Cultivation.—Cutting; peeling; preparation for use.

The Break.—Willow Bolt. Testing rods, sorting, buying. Names of sizes commercially.

B. Tools and their uses.

C. Principles and Methods employed in making Round and Oval Baskets.

1. **Bottoming**:—Terms, proportion, laying slath; tying it, splitting it, pairing, sleaping, measuring, picking, exercises in bottoms; questions, &c.

2. **Staking**:—Proportion, cleaning, number, pointing, insertion, pricking, crowning.

3. **Upsetting**:—Tools—number rods, proportion, method.

4. **Siding**:—Various strokes, proportion warp, woof when preferred, randing, ribranding, slewing, waling, fitching. How to finish. Control of slakes, sore fingeredness. Kinks, rigidity, elasticity. Terms defined:—slake, bye slake, leagues, flow. Tools required—picking.

5. **Bordering**:—Kinds in use; when each preferred. How to recognize plain border, upright, plaited, rope, scallop. To learn to work upright border, but others only if capabilities allow. Tools required. Method, slake rods, bow rods, pegging, picking.

6. **Handling**:—Cleaning rods, selection. Tools required, kinds of handles, side, over, skeined. Methods, side handles on border, below border, lower down basket. Over handles, methods; skein handles methods.

7. Making articles of round and oval work, according to directions given and specifications noted beforehand.

PART III.

SPECIMEN SYLLABUSES OF COURSES OF INSTRUCTION (ART).

Primary Course.

A Primary Course of Drawing is considered to consist of Freehand Drawing with pencil and brush in outline, shapes in silhouette with the brush, from flat examples, from Common Objects of simple form, simple Plant Forms (single leaves, flowers, fruits), letters (Roman, Gothic, etc.), and from casts of simple Ornament, together with simple studies of light and Shade in respect of the above mentioned common objects and casts of ornament, accompanied by drawing with rulers and instruments, such as Geometrical Drawing (Art), drawing simple constructions from measurements, etc., drawing to Scale and Perspective (simple problems).

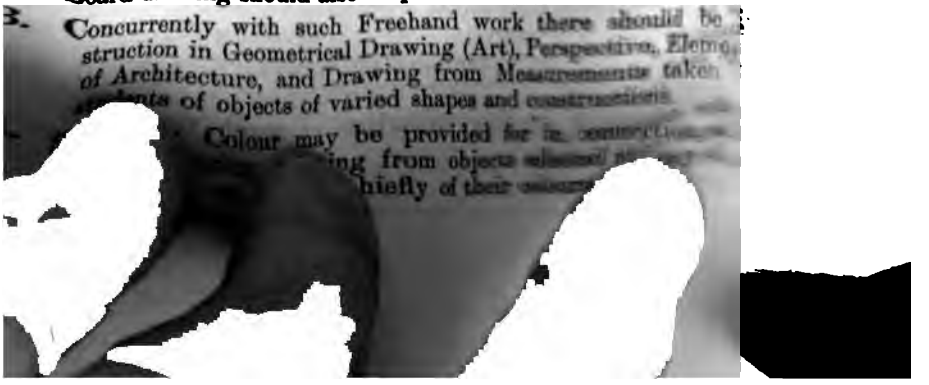
Later on the Primary Course should provide for—Practice in drawing diagrams to large scale on the blackboard, and Modelling (as indicated in subject 18a), in addition to practice in Freehand Drawing and drawing with rulers and compasses as above.

Secondary (Advanced) Course.

A Secondary (*i.e.* Advanced) Course should provide for progressive instruction and practice in Drawing, Painting and Modelling, in respect of work as indicated below. The study of Principles of Ornament and making arrangements of form and colour with ornamental aim, should be taken early in the course and if possible by all students entered for the course.

A. Freehand Drawing including studies of light and shade with pencil, pen and brush from growing plants (together with studies in analysing the structure of plants): Various objects of household use, etc., singly and also in groups: Casts of Architectural Ornament, *e.g.* complete panels, capitals, friezes, and such like (together with study of their position on and relation to the buildings or monuments they come from): From casts of details of the human figure from the Antique and the Life, and from casts of complete Antique figures.

Blackboard drawing should also be practised.


3. Concurrently with such Freehand work there should be
struction in Geometrical Drawing (Art), Perspective, Elem
of Architecture, and Drawing from Measurements taken
of objects of varied shapes and
Colour may be provided for in
from objects
chiefly of their

Modelling in various degrees of relief, and in the round from casts of ornament, from plants (with studies of structure of plants), from casts of details of the human figure from the Antique and the Life, and of complete Antique figures should be taken as part of the general work in the Course.

As students obtain facility in carefully observing and representing (by Painting, Drawing, and Modelling) details of the human figure and the complete Antique figure, instruction and practice in Anatomizing such details and figures should be arranged.

More Advanced or Technical Course

A still more Advanced or Technical course should enable students to continue their practice in the Secondary Course and to receive regular instruction in a systematic study of Historic Ornament from actual objects, as far as local and other circumstances permit, together with more advanced study in Principles of Ornament and practice in deducing them from the study of actual examples, and in using them in making designs for various articles of use, etc.

Provision should be made in this Course for students to practise Drawing, Painting, and Modelling from the Life, and from Draperies cast on both Antique and Living models in conjunction with which Students should have instruction and practice in the Decorative treatment (Drawing, Painting and Modelling) of the human figure in connection with buildings, articles of use and such like, and thus be led on to specialize, where desired, in one or two of the following subjects—

Architectural Design.

Design (Painting, Drawing, and Modelling) in relation to objects of use and to personal adornment.

Decorative Design (Painting, Drawing, and Modelling) in relation to Buildings.

[As regards instruction for "Applied Designs" (23. c. d. e. and f., p. 245), it is undesirable to encourage students to make designs on paper or in plaster without any knowledge of their suitability for execution in the material to be employed. Facilities, therefore, should be afforded wherever possible for students to carry out so much of their own designs, or to see so much carried out, as will show whether they are suitable to the material.]

The Sub-Divisions of Subjects of Art for Classifying School Work are as follows—

1. Linear Drawing by aid of Instruments.

1*a*. Linear Geometry (including problems in Practical Plane and Solid Geometry and Graphic Statics).

1*b*. Machine and Building Construction and Naval Architecture—Drawings from copies.

1*c*. Linear Perspective.

1*d*. Architecture—Drawings from copies.

1*e*. Sciography.

2. Freehand Outline Drawing of rigid forms from Flat Examples.

a. Objects.

b. Ornament (showing elementary principles of design).

3. Freehand Outline Drawing from the "Round."

a. Models and objects.
b. Ornament.

4. Shading from Flat Examples.

a. Models and objects.
b. Ornament.

5. Shading from the "Round" or Solid Forms.

a. Models and objects.
b. Ornament.
c. Drapery.
d. Time sketching and sketching from memory.

6. Drawing the Human Figure and Animal Forms from Flat Examples.

a. In outline.
b. Shaded.

7. Drawing Flowers, Foliage, and Objects of Natural History from Flat Examples.

a. In outline.
b. Shaded.

8. Drawing the Human Figure, or Animal Forms, from the "Round" or from Nature.

a. In outline from casts.
b^1. Shaded (details).
b^2. Shaded (whole figures).
c^1. Studies of heads, hands, and feet from life.
c^2. Studies of the human figure from nude model.
d. Studies of drapery arranged on figure from antique or on the living model.
e. Time sketching.
f. Sketching from memory.

9. Anatomical Studies of the Human Figure or of Animal Forms.

a. Students' own setting of bones and muscles drawn or painted within the outline of a figure.
b^1. Drawn or painted from the skeleton or anatomical figure.
b^2. Drawn or painted from copies.
c. Students' own setting of bones and muscles, modelled.
d^1. Modelled from the skeleton or anatomical figure.
d^2. Modelled from the flat.

10. Drawing Flowers, Foliage, Landscape Details, and Objects of Natural History, from Nature.

a. In outline.
b. Shaded.
c. In monochrome.
d. From memory.

11. Painting Ornament from Flat Examples.

a. In monochrome
b. In colours
} either in water-colour, tempera, or oil.

12. Painting Ornament from the Cast, &c.

a. In monochrome, either in water-colour, oil, or tempera.

13. Painting from Flat Examples—Flowers, Still-Life, &c.

a. Flowers or natural objects, in water-colour, in oil, or in tempera.
b. Landscapes or views of buildings.

14. Painting direct from Nature.

a. Flowers, or still-life, in water-colour, oil, or tempera without backgrounds.
b. Landscapes, or views of buildings.
c. Drapery.

15. Painting (from Nature) groups of Still-Life, Flowers, &c., as Compositions of Colour.

a. In oil-colour.
b. In water-colour or tempera.
c. In monochrome, or light and shade.

16. Painting the Human Figure or Animals in Monochrome from Casts.

a. In oil, water colour, or tempera.

17. Painting the Human Figure or Animals in Colour.

a. From the flat, or copies.
b. The Head or draped figure from nature.
c. The nude figure from nature.
d. Time sketches.

18. Modelling Ornament.

a. From details, such as single ornamental devices, scrolls, &c.
b. From casts of ornamental compositions for pilasters, friezes, &c.
c. From drawings or photographs.
d. Time sketches from examples.
e. Modelling from memory.

19. Modelling the Human Figure or Animals.

a. Hands and feet from casts.
b^1. Heads and masks from casts, in the round, or from casts in relief.
i. Heads and masks in relief from casts in the round.
b^2. Whole figures from casts of figure in the round, or from casts of figure in relief.
k. Whole figures in relief from casts of the figure in the round.
c. Modelling the figure or animal forms from the flat.
d. Heads, hands, and feet from nature, in the round.
" " " in relief.
e. The human figure from the nude model in the round.
h " " " in relief.
f. Modelling drapery from actual stuffs and not from casts.
g. Modelling from memory.

20. Modelling Fruits, Flowers, Foliage, and Object of Natural History, from Nature.

21. Time Sketches in clay of the Human Figure, or Animals, from Nature.

22. Elementary Design.

a. Studies treating natural objects ornamentally.

b. Ornamental arrangements to fill given spaces in outline monochrome, or modelled.
c. Ornamental arrangements to fill given spaces in colour.
d. Studies of historic styles of ornament drawn or modelled.
e. Studies in lettering.

23. Drawings from Actual Measurements of Structures Machines, &c., Applied Designs, Technical or Miscellaneous Studies.

a. Architecture and building construction—drawings from actual measurements, taken by the students, of existing structures.
b. Architecture and building construction—original designs.
c. Ornamental design as applied to decorative or industrial art.
d. Figure composition, and ornamental design with figures, as applied to decorative or industrial art.
e. and *f.* The same as 23*c* and 23*d*, but in relief.
g. Machine construction and naval architecture—drawings from actual measurements, taken by the student, of existing machines, ships, &c.
h. Machine construction and naval architecture—original designs.

24. Examples of Works executed in the actual materials by the students themselves from their own designs:—

a. Wood—carved, inlaid or incised, charred ar stained.
b. Metal—repoussé, chased, engraved, pierced or enamelled jewelry.
c. Leather work—embossed or cut.
d. Gesso work.
e. Embroidery—lace, cut and drawn work, textile fabrics.
f. Pottery, tiles, glass.
g. Miscellaneous works.

MEMORANDUM ON COURSES IN ART FOR EVENING SCHOOLS.

GENERAL DRAWING COURSE.

Drawing. A general drawing course, suitable for students attending Evening Schools, might be derived from the Circular upon Primary Drawing which has been published with notes and illustrations, and may be obtained from Messrs. Eyre and Spottiswoode, price fourpence halfpenny.

Such a general course should provide for practice in Freehand Drawing with pencil, pen and brush in representing the structure and shapes of things (1) in Silhouette, and (2) in Outline, and in drawing with instruments to scale, in plan, elevation, and section and in perspective, which should, as a rule, be concurrent with Freehand Drawing; practice in modelling from simple subjects should also come into this course.

SPECIAL COURSES.

The Council of Advice for Art recommend that where it is possible the Master of the local School of Art should generally supervise this course.

Courses specially adapted for students who are engaged in various occupations, such as Carpentry and Joinery, Ironworking, Gardening, Printing, etc., may be framed as indicated.

Drawing for those engaged in Carpentry, Joinery, etc. A course for those engaged in Carpentry would probably include study of the constructional lines of such objects as a trestle, a table, a chair, a bench, a chest, a hanging cupboard; the study of the treatment of palings, drip-boards, lattices, window-frames, etc.

Drawings, both freehand and with instruments to scale, should be made of such objects in addition to freehand drawings with pencil, pen and brush in outline and silhouette of simple floral forms.

Drawing for those engaged in Ironworking.

For those engaged in Ironworking the course should involve the study and drawing of the elements and characteristic forms used in iron construction, such as the simple grill and railing; the study of the forms into which the bars may be bent or hammered, and of the treatment suitable for finials, spirals, handles, hinges, sign brackets, etc., and drawings and models should be made of good examples of such things.

Drawing and Design for those engaged in Painting, Decorating, Sign-writing, Printing Engraving, etc.

For those engaged in Painting and Decorating, in Sign Painting, Printing, Engraving, etc., the treatment and spacing of various types, such as Capitals and Lower Case, should be studied in respect of name plates, shop signs, tickets, notices, bill-heads, scrolls, borders, stencils and inscriptions. Heraldic devices should also be studied as well as their ornamental value in connection with lettering generally.

Drawing for those engaged in Embroidery.

For those engaged in Embroidery the course might include freehand drawing in outline and silhouette of floral forms, also the study of how to treat these forms for embroidery, and attention should be given to the methods of indicating the various sorts of stitches.

Drawing for those engaged in Carving and Modelling.

For those engaged in Carving and Modelling the course should include the study of forms suitable for wood and stone carving, and the particular treatments required for different materials.

Drawings and models should be made of relief ornament on different surfaces, such as those of a cube, a cone, and a sphere, with the aim of understanding the way in which such varied conditions may be met.

Studies should be made of plants and leaves, and of their adaptation to convex and concave types of architectural capitals. The course would probably include the study of the different treatments for incised and raised inscriptions, wood and stone mouldings, barge boards, carved panels and doors, bench ends, and tombstones.

Drawing and Design for those engaged in Plasterwork, Moulding, etc.

For those engaged in plasterwork, building, etc., the course would probably include the study of the treatment of natural forms in modelling and plasterwork, and attention would be given to various types of borders and mouldings, plain and enriched, of panels, mouldings, cornices and friezes, spandrils, etc., and panels with armorial devices. *Drawings to scale and sections should be made.*

For those engaged in Glazing and Plumbing.

For those engaged in Glazing and Plumbing, drawings would be made of simple geometric patterns and of floral forms adapted to them, as well as of such forms controlled by geometric plans suitable for plain leading in windows. Attention should be directed to other lead work, such as that which may be used for gutters, pipes, rain-water heads, cisterns, window-boxes, etc.

For those engaged in Pottery, Turning, Coopers' work, Glass-blowing, and Tin-working

For those engaged in Pottery, Turning, Coopers' Work, etc., Glass-blowing and Tin-working the course should probably include the study of the various types of vessels in wood, glass, and metal, and the consideration of the main typical principles of form in vessels: (1) the cylindrical; (2) the conical; and (3) the oval. These may be observed in natural forms, such as seeds, flowers, fruit, etc., and the application of them in vessels of common use in their different functions as carriers, holders, dippers, pourers, fillers, &c.

Drawings of floral forms should be made with the brush, and surface patterns suitable to pottery should be studied. The positions and proportions of pottery decoration should be studied, and, as a rule, the constructional and functional parts of the objects should be selected for ornamental emphasis. Attention should be given to treatment of plate borders, and of patterns for sgraffitio, for painting and printing slip and modelling on pottery.

For those engaged in Building.

For those engaged in Building, the course would probably include the making of plans, sections and elevations of a country cottage with garden, etc., and the study of brick and tile work, gates and hedges, etc.

For those engaged in Gardening.

For those engaged in Gardening, the course should include the study and drawing of plans of formal gardens, the forms of trellises, and the consideration of the treatment of formal hedges, borders, etc., and the shaping of trees.

The foregoing Memorandum, with illustrative diagrams, will be published separately.

PART IV.

LIST OF APPARATUS SUITABLE FOR USE IN SCIENCE CLASSES.

This list has been prepared for the guidance of teachers and managers in charge of Science classes, and it is to be regarded as comprising such apparatus as would be required for the proper demonstration of the various subjects, in accordance with the syllabuses contained in Part I.

SUBJECT I.—PRACTICAL PLANE AND SOLID GEOMETRY.

1. Each student must be provided with a drawing board, T square, 45° and 60° set squares, set of mathematical instruments, set of five decimal scales in which the unit divisions are respectively 1″, ½″, ¼″, ⅛″, and 1 centimetre; a pricker and a protractor. Also with drawing paper and tracing paper, and with two hard pencils, and a piece of the finest sandpaper for sharpening the same. In connection with each class there should be a trying plane provided, to which the students have access, for the purpose of setting their straight-edges and squares.
2. Black board (preferably hinged), and Black board T square.
3. Models illustrating the meaning of vector addition and vector subtraction; and apparatus to verify experimentally the principle of the triangle of forces and the polygon of forces.
4. Hinged models of the three planes of reference or projection, showing how a point, a line, and a plane are represented by projection, and illustrating simple problems connected with them.
5. Students should be provided with facilities to enable them to make simple models in paper, like those specified in 4, to illustrate their own work.
6. Wire models of triangles, square cube, and triangular and square prisms.

STAGE 2.

The following apparatus in addition to those mentioned for stage 1 :—

7. Apparatus to verify experimentally the principle of the link polygon, in the case of a string in equilibrium under the action of several loads applied at different points.
8. Wire models of the regular tetrahedron, regular octahedron. Models of the sphere, right circular cone and right circular cylinder, showing the forms of the various sections.
9. Model to illustrate the meaning of perspective projection and the principle of vanishing points.

SUBJECT II.—MACHINE CONSTRUCTION AND DRAWING.

1. Students should be provided with drawing board; T square; 45° and 60° set squares; set of mathematical instruments; hard pencils and piece of glass paper for sharpening the same; protractor; set of eight scales subdivided into eighths, the lengths of the main divisions of which are respectively 1″, ½″, ¼″, ⅛″, ¾″, ⅜″, ½″, and ⅝″. Tracing and drawing paper and squared paper for sketching. Piece of Indian ink and saucer. Callipers and two-foot rule.
2. The class should be provided with sets of easy copies suitable for tracing, from which the student may practise lining and inking in.
3. Simple actual examples of machine details (not models) which the students can take to pieces, and measure and sketch, and afterwards make working drawings from their own sketches. Such, for example,

as a bolt and nut, a riveted joint, a pulley, a pedestal, a bracket, a hanger, a piston, a crosshead, an eccentric, a connecting rod end, a slide valve, an unwound electric motor or dynamo machine, a commutator, etc., etc. Many of these might be obtained from local manufacturers.

4. Good examples of working drawings permanently exhibited on the walls of the room.
5. Facilities for enabling a student to take a photographic print of one of his tracings.
6. An oil stone and a trying plane, available for the use of students for the purpose of setting their instruments.

SUBJECT III.—BUILDING CONSTRUCTION.

1. Each student must be provided with a drawing board, T square, and other drawing instruments and drawing materials.
2. The doors, windows, &c., of the building and neighbouring buildings will furnish some models, but it will be advisable to get some good working drawings, tracings, and blue prints, if possible, from local architects.
3. One or two good tape-lines and two-foot rules. Students should as soon as possible make drawings from their own notes, sketches, and dimensions.
4. Some of the beautifully illustrated manufacturers' catalogues of building goods.
5. One or more builders' price books.
6. Samples of woods, stones, bricks, tiles, slates, cements, &c., with maps showing locality of origin.
7. Apparatus for making blue prints.
8. A sheet of diagrams showing graphic methods of calculating stresses in trusses and girders; to be hung up.
9. For the walls a set of good drawings of the ancient orders, mouldings, and ornaments; and of special bits of English, &c., architecture; the whole illustrating the history of European buildings during the time covered, and these should be framed and glazed. Wall pictures of complete buildings not advisable.
10. Some test tubes, a Bunsen burner, and a few bottles and reagents for simple experimental work, with stones, cements, &c.; a basin, tap, and waste.
11. Cement-testing apparatus.
12. Proper supports for drawing boards, tables, and some seats.
13. A good black board, with sliding squares and black board drawing instruments.

SUBJECT IV.—NAVAL ARCHITECTURE.

It does not appear that (beyond the provision of drawing apparatus for each student, together with curves of long radius) any apparatus can be specified. Presumably all students of this subject will be engaged in the industry, and will be familiar with the structures which enter into their designs. Sectional models of well designed vessels would clearly be of value, but the cost of these would generally be prohibitive.

Specimens of the methods of construction, joints, rivets, sections of rolled iron.

SUBJECT VI. *a*.—THEORETICAL MECHANICS.—SOLIDS.

STAGE 1.

Balance and weights, metre-sticks (to show the difference between "end-measure" and "line-measure," one stick a metre long and another showing the engraved lines 1 metre apart as in the actual standard), graduated measuring jar, burette.

Model vernier.

Small geometrical solids of different materials for estimation of lengths, areas, volumes, densities.

* Hare's apparatus and U tube for equilibrium of two different liquids.

* Specific gravity bottle.

Spring balance, spiral spring, and a dynamometer (india-rubber).

Means of demonstrating the parallelogram of forces.

Hicks's ballistic balance.

Apparatus to show the acceleration of bodies falling in vacuo.

Simple pendulum, compound pendulum.

Atwood's machine.

Inclined plane (hinged so as to be capable of adjustment).

Levers, model of common steel yard, single pulleys, and a pair of compound pulley blocks having three pulleys in each block.

Wheel and axle, wedge, screw, spherometer, screw gauge, and sliding callipers.

Apparatus to show resistance to (1) elongation, (2) compression, (3) bending, (4) torsion. Apparatus for study of moments, &c.

STAGE 2.

Any school which has an advanced class should possess all the apparatus mentioned under the elementary stage, and should also have blocks of different material (wood, metal, leather, &c.) for demonstrating the laws of friction and for measuring the coefficient and angle of friction with the aid of the adjustable inclined plane.

Model to show how indicator diagrams are obtained.

SUBJECT VI. *b*.—THEORETICAL MECHANICS.—FLUIDS.

STAGE 1.

Apparatus marked * in list for Mechanics of Solids, and—

Flask with side tube.

Hydrometers (Nicholson's, &c.)

Glass cylinder open at both ends, with brass supports at one end and a movable base for demonstrating variation of pressure with depth of a liquid.

Apparatus to show equilibrium of liquid in communicating vessels.

Pascal's vases or their equivalent.

Apparatus to demonstrate the principles of flotation and stable and unstable equilibrium (rods, blocks, &c.)

Flask, &c. to show that air has weight.

Barometer tube, Mercury basin, scale.

Bourdon's metallic barometer to show principle of steam gauge.

Boyle's-law apparatus.

Pressure gauge, siphon gauge, mercury gauge.

Sprengel's air-pump.

Glass models of siphon, suction-pump, force-pump.

Thermometers and simple calorimeter.

STAGE 2.

Apparatus for demonstrating the coefficient of expansion of air due to change of temperature, by means of experiments on a quantity of air (*a*) under constant pressure, (*b*) at constant volume.

Regnault's hygrometer.

Apparatus for demonstrating capillary phenomena.

SUBJECT VII.—APPLIED MECHANICS.

Models or actual specimens of the more important mechanisms used in transmitting power; there ought, if possible, to be means for measuring velocity ratio and efficiency of transmission of power.

Models or actual specimens of lifting machines, such as screw and hydraulic jacks, cranes, pulley blocks, Weston pulley block, inclined plane, etc., arranged so that their efficiencies may be measured under very different kinds of loading. Waste of energy in using a simple pulley; in the rolling of the wheel of a bicycle, in the hub of a cycle with roller bearings.

Quantitive illustrations of the triangle and Polygon of Forces; principle of moments; the lever; friction between solids with and without lubrication, friction in fluids; forces in parts of a hinged structure; centrifugal force; friction between a belt and a pulley; the balancing of rotating things.

Transmitting and absorbing dynamometers; efficiency of a motor worked by water; efficiency of an electric motor.

Attwood's machine; apparatus to show the relation between kinetic energy and speed of a fly wheel; momentum before and after impact of two bodies; to illustrate rule as to time of vibration of a body, and the stilling of vibrations by fluid friction; the laws of forced vibrations.

Surfaces of metals, timber, and other materials arranged for examination by magnifying glasses or microscopes.

Apparatus enabling the stiffness of springs to be measured.

Simple apparatus for comparing stress and strain in material till it is broken; in tension, compression, shearing, twisting, bending.

Apparatus to measure rise of pressure due to more or less sudden stoppage of water flow in a pipe.

Models of a centrifugal pump, of a jet pump, and of a turbine, to be taken to pieces and drawn by students. Measurement of flow of water from orifices and over gauge notches. Model allowing pressures to be measured at various points along a pipe of varying section; to measure force due to a flowing jet of water.

There should be good means for making measurements of length and weight of objects usual in workshops or laboratories.

Squared paper to be used in finding the relation between quantities measured in the experiments. Any of the laboratory apparatus may be exhibited on the lecture table. A heavy ball hanging by a steel wire from the ceiling illustrates many things; beams and shafts of india rubber are useful to a lecturer.

Students derive much greater advantage from carrying out experiments themselves than from merely looking at models.

SUBJECT VIII.—SOUND, LIGHT AND HEAT.

Instructions by which the teacher can, at little expense, set up pieces of apparatus for himself, are given in the "Outline of Experiments and Description of Apparatus and Material," suitable for illustrating elementary instruction in this subject, published by the Board of Education and obtainable from Messrs. Eyre and Spottiswoode, London, price 6*d*.

Stage 1.

Sound.

Monochord with two strings, one with pulley to carry weights. Set of weights, 1 lb. to 14 lb. Tuning key.

Brass and steel piano wire of various thicknesses.

Pair of flat-nosed pliers.

Two or three tuning forks, the larger the better, with resonance boxes; violin bow.

Apparatus to show wave lines traced on smoked glass.
Round rods of wood, 5 or 6 feet long, and about $\frac{3}{4}$-inch diameter.
Rosin, flexible leather, soft wax, bristles.
Thin board of pine. Long thin wooden lath.
Vice or clamp for fixing rods and vibrating bodies to the table.
Knitting needles, bright steel rod, twisted steel spring, bright silvered beads.
Row of marbles in a groove, or solitaire board.
Long spiral spring of wire supported horizontally by threads attached to a frame.
Long caoutchouc tube, with ring for attaching to ceiling or wall.
Two tinned iron tubes about 3 feet long, with supports.
Simple form of Savart's wheel and siren, or a top mounted with toothed wheel and perforated disc.
Air-pump, receiver, and bell, to show effect of rarefied air on sound.

Light.

Lantern and screen (or large sheet of cardboard).
Cap to lantern with slit.
Grease-spot and shadow photometers.
Pin hole camera.
Pieces of plane silvered glass (plate, or patent plate).
Apparatus to illustrate laws of reflection, preferably for use with lantern.
Apparatus to illustrate laws of refraction, preferably for use with lantern.
Two inclined mirrors, mounted on board with divided circle. Concave and convex spherical mirrors on stands.
Set of lenses of various forms, convex and concave, with holder; 60° prism of glass; 60° prism of bisulphide of carbon; two glass wedges: total reflection prism.
A piece of thick plate glass, or a glass slab.
Batswing burner on stand, with flexible tube (where gas supply is available); wax candles, cardboard, &c.
Glass cell to hold liquids.

Heat.

Glass beakers (1 doz. assorted); glass flasks (three or four of 4 oz. capacity, several larger): glass tubing (about one pound of quill tubing, a few lengths of larger size, and of alcohol thermometer tubing); one or two small glass funnels.
Mercury; methylated spirit and aniline to colour it; salt, nitre, sulphate of soda, &c. A supply of ice should be arranged for.
Bunsen burner and flexible tube, or large spirit lamp.
Retort stand, with rings and clamp. Iron tripod stand. Sand bath. Pneumatic trough, or stoneware basin.
Two thermometers, chemical form, $-10°$ to $110°$ C.
Hypsometer. [Barometer.]
Compound metal bar to show effect of unequal expansion.
Ball and ring, or rod and gauge, to show linear expansion.
Apparatus to illustrate method of measuring expansion of a solid rod.
Apparatus to illustrate method of measuring absolute expansion of liquids.
Apparatus to show maximum density of water.
Differential air thermometer. Simple form of air thermometer.
Balance on stand, with set of brass weights, 500 gm. to 0·1 gm.
Calorimeter of thin brass or copper. Some open tin cans.
Small cylinders of various materials, all of equal size (wood, cork, glass, lead, iron, brass, copper, &c.)
Pieces of lead of about $\frac{1}{2}$ lb. or 1 lb., cast in blocks, with hooks attached.
Block of iron of 1 lb. weight, with hook attached.
Copper ball, with hook.
Tin can fitted with cork and delivery tube for experiments on latent heat. [Air pump and receiver to show water boiling under reduced pressure.]

SUBJECT X.—INORGANIC CHEMISTRY.

For the purposes of lecture demonstration a sufficient supply of glass and other apparatus, including diagrams, required for illustrating the subjects enumerated in the several syllabuses, must be provided.

For experimental work to be done in the laboratory by the students each working place should be furnished according to the following list:—

Conical brass blow-pipe, with bone mouthpiece.
Platinum wire, 6 inches.
Platinum foil, 2 inches long, 1 inch wide.
Test tube stand, 12 holes and 12 pegs.
Test tubes, 30 of 6 inches by $\frac{3}{4}$-inch.
Test tubes, 12 of 5 inches by $\frac{3}{4}$-inch.
Conical flasks, 2, 8 oz., with wide necks, for use with filter pump.
Test tube brushes, 2.
Beakers, a set of 5, 4 oz. to 16 oz.
German flasks, 1 each—2 oz., 4 oz.; 2 each—8 oz. and 16 oz.
India-rubber stoppers with 2 holes to fit each of the two largest flasks.
Royal Berlin porcelain crucibles, $1\frac{1}{4}$ inch and $1\frac{1}{2}$ inch.
Best German porcelain evaporating basins, 1 each—$2\frac{1}{4}$ inch, $3\frac{1}{2}$ inch and 4 inch.
Funnels, 2 of $2\frac{1}{2}$ inch, 1 of 2 inch.
Funnel holder for two funnels.
Filtering paper, 1 packet each 7 c.m., 9 c.m., and 11 c.m. diameter.
Two iron tripod stands, 8 inches high, one round, one triangular.
Iron retort stand, 20 inch, with three rings and clamp.
Iron gauze, 5 inches square, 2 pieces, with asbestos interwoven.
Sand bath, 5 inch, tin plate.
Watch glasses, 2 inches, 6.
Desiccator.
Glass tubes, soft, $\frac{3}{16}$ to $\frac{1}{4}$ inch diameter, $\frac{1}{2}$ lb., in lengths of about 2 feet,
Thin glass rods, $\frac{1}{8}$ to $\frac{3}{16}$ inch diameter, $\frac{1}{4}$ lb., in lengths of about 2 feet.
Black caoutchouc tube, $\frac{5}{16}$ inch bore, 4 feet.
Black caoutchouc tube, $\frac{1}{8}$ inch bore, 2 feet.
Corks, 2 doz., assorted.
Triangular file, 5 inch, in handle.
Round file, 5-inch, in handle.
Pair of scissors.
Bunsen's gas burners, 2, with regulators for gas and air with blow-pipe jet, star support, chimney, and rose.
Bowed crucible tongs, brass, 7 inches.
Composition mortar, 4 inch.
Cobalt blue glass, 4 pieces, $1\frac{1}{2}$ inches square.
Cork borers, set of three.
Two horn spatulas, 3 inch and 4 inch.
Three test paper rolls, 1 red, 2 blue litmus.
Two dusters.
Drying cone.
Two pipe triangles.
Two weighing bottles.
Three clock glasses.

Balances, weights, thermometers, burettes, and other graduated vessels, electric current, with means of regulating and measuring the current used in electrolytic experiments, and a stock of re-agents must be supplied for general use.

SUBJECT XII.—GEOLOGY.

Each school should have the ordnance maps in all scales of the country round, and also all maps, sections, and memoirs of the Geological Survey relating to that particular district.

Typical collection of igneous, aqueous and metamorphic rocks, of rock-forming minerals, and of fossils. These might include :—

IGNEOUS ROCKS : Granite, syenite, diorite, gabbro, rhyolite, trachyte, andesite, basalt, obsidian, pumice, tachylite, picrite, lherzolite, granitite, dolerite, &c.

AQUEOUS ROCKS : Sandstone, conglomerate, micaceous flagstone, clay, shale, slate, chalk, oolitic limestone, crystalline limestone, rock salt, gypsum, stalactites, stalagmites, pisolitic limestone, coral, calcareous tufa, siliceous sinter.

METAMORPHIC ROCKS : Gneiss, hornblende schist, mica schist, clay slates, quartzite, granulite, marble, serpentine.

Geological maps of the British Isles and of the district. Microscope and slides of Radiolarian ooze, diatom ooze, globigerina ooze, desert sand, granite, basalt, obsidian, trachyte, serpentine, oolitic limestone, quartzite, crystalline limestone, clay slate, mica schist with garnets, micaceous gneiss, &c.

A geological hammer, standards of hardness, some hydro-chloric acid, a blowpipe, &c., should also be included.

SUBJECT XIII.—MINERALOGY.

A set of models illustrating the different crystallographic systems, contact goniometer, Miller's simple reflecting goniometer, microscope, apparatus for showing properties of light, polariscope, examples of double refracting bodies, specific gravity solutions, specific gravity bottle, spring, &c., balances, blowpipe, &c., borax-beads coloured by metallic oxides, scale of hardness, and a set of typical minerals, as already shown in the Syllabus.

SUBJECT XIV.—HUMAN PHYSIOLOGY.

1.—STAGE 1.

A. *Body Structure.*—Large diagrams of the general arrangements of the parts of the human body.

The following bones of some animal, such as the rabbit, viz. : Skull, some vertebræ, some ribs, shoulder and hip bones, limb bones. Such parts of the human skeleton as can be obtained ; some decalcified long bones. Specimens of the following organs dissected out from a rabbit, and kept in spirit for illustrating lectures :—The lungs, liver, kidneys, spleen, stomach cut open ; similar specimens obtained from a butcher of the sheep's trachea, heart, piece of aorta, piece of large vein, vein turned inside out, to show valves. (It is very desirable that when any of these organs are dealt with in lectures, fresh specimens should be obtained from a butcher. The sheep's organs are quite suitable, and should be cut open to show the arrangement of the parts).

Two or three hand lenses for examining fresh specimens of organs, and for inspecting mounted slides of bone sections, &c.

Mounted sections of bone, liver, lung, trachea, kidney, and spinal cord for examining with hand lens.

A microscope with 1-inch and $\frac{1}{8}$-inch objectives for examining thin films of dilute human blood and of cows milk ; mounted microscopic specimens of the following tissues, viz. : bone, cartilage, skin, tongue (for muscle) œsophagus (for mucous membrane), liver (if possible injected), and a nerve trunk in cross-section.

B. *Food and its Digestion.*—The following chemical appliances and re-agents :—

(1.) A centigrade thermometer (scale 0 to 100° C.).

(2.) Bunsen burner or spirit lamp, tripod, small enamelled iron basins, test tubes.

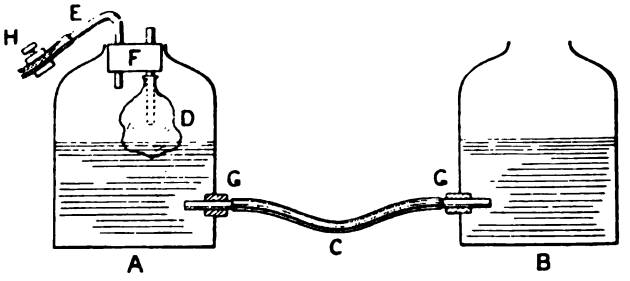
(3.) Litmus paper (red and blue), HCl (0·3%), Na Ho (5%), Cu SO_4 (diluted), Na_2CO_3 (1%), iodine, lime water.

(4.) Materials for digestive changes, starch, grape sugar (dextrose), liquor pepticus (Benger), liquor pancreaticus (Benger), fibrin. (The fibrin can be got from a slaughter-house from whipped blood, it should be well washed and then preserved in glycerine; before treating it with digestive agents it should be freed from glycerine by soaking in water.)

C. *Respiration, &c.*—Lime water to be gently blown into by means of a glass tube.

A clinical thermometer for ascertaining temperature in mouth.

Two glass bottles, each with two apertures, to be fitted up as shown in the annexed figure for illustrating the mechanism of respiration. India-rubber tubing, glass tubing, and a screw clip.



A and B. Bottles with openings at the top and side openings at base.

C. Piece of india-rubber tubing, with glass tube on each end fitting into corks G, which tightly close side openings of bottles.

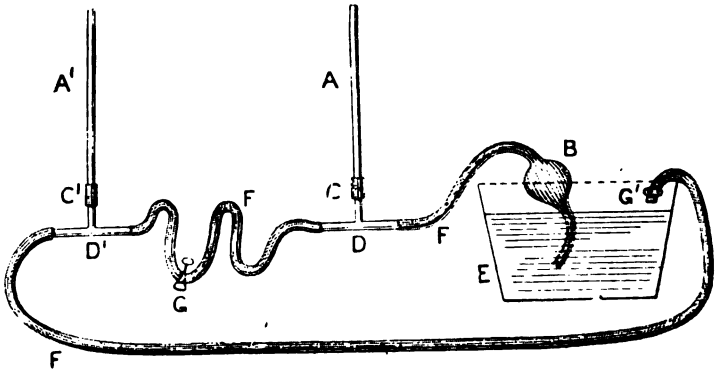
D. A thin toy balloon tied on to a glass tube which fits into cork F. (If possible, the lungs of a dead rabbit should be carefully cut out with the trachea, and the trachea tied on instead, as the demonstration is then far more instructive.)

E. A piece of glass tube with a piece of india-rubber tubing on the end of it, which can be blocked up by a screw clip (H).

F. A good cork with two holes bored in it, tightly fitting into the bottle A.

The apparatus is used by filling both bottles to the level shown with water, having H open; then H is closed and bottle B lowered; as the water runs out of A the balloon D (or the lungs) enlarge.

D. *Circulation.*—Glass tubing, india-rubber tubing (about 5 yards), two glass T pieces, two screw clips, and an india-rubber enema syringe provided with valves, such as is sold by every chemist. The following apparatus for illustrating the mechanism of the circulation can then be constructed.



A, A′. Two glass tubes, from 2 to 3 feet long, to be fixed vertically: They should be about ¼ to ½ inch wide.

B. The elastic enema syringe, sold by all chemists, and provided with valves.

C, C′. India-rubber junctions connecting A and A′ with glass T pieces D, D′.

E. Bowl of water.

F. Lengths of india-rubber tubing connecting enema syringe and other parts, as shown in figure.

G, G′. Two screw clips, for compressing the india-rubber tubing at G and G′.

The apparatus is used by squeezing B at successive intervals, thus forcing water through tubes; it rises up the tubes A, A′ and pulsates up and down. By compressing G with screw clip the liquid in A can be made to rise still higher, whilst that in A′ falls, the water in A pulsates strongly, that in A′ hardly at all; A represents arterial, A′ venous system, G the capillaries.

The Eye.—Two convex lenses of different strength, a white screen for showing the focussed image of (*a*) a bright window (*i. e.*, parallel rays); (*b*) a luminous object (lamp) placed nearer the lens, a piece of millboard having a small aperture in the centre to represent the pupil. The screen, the millboard, and the lenses should be fixed on simple wooden blocks, and these should slide along against a long wooden lath, so as to keep their centres in the same line.

The eyeball of the ox opened and kept in spirit. The fresh ox eyeball should always be shown; one such eyeball should be opened and the lens cut out; the magnifying power of the fresh lens is demonstrated by placing it on a piece of paper printed in small type and seeing the letters enlarged.

II.—Stage 2.

Microscopic specimens of the tissues and organs not given in the elementary list, including areolar, elastic, and fibrous tissue, blood vessels of mesentery, stomach, small intestine, kidney, bladder, lungs, trachea, pancreas, salivary gland, thyroid gland, spleen, voluntary and involuntary muscle fibres, nerve fibres, spinal cord, medulla, cerebral cortex, the cornea, the retina, &c.

Specimens of organs of the body kept in spirit, and not given in the elementary stage list: such as the larynx cut open to show the position of the vocal chords, &c.

Apparatus and Chemicals.—The following additional chemical agents for ascertaining the characteristic properties of the substances present in food stuffs, in blood serum, in bile, and in urine, viz.:—

(*a*.) 10% Na Cl for extracting the proteids of fresh meat and of lentils.

(*b*.) Saturated solutions of ammonium sulphate and of magnesium sulphate, methylated spirit, acetic acid, strong HNO_3, Millons re-agent (*i.e.*, mercuric nitrate mixed with HNO_3) for precipitating proteids.

(*c*.) H_2SO_4, and cane sugar for bile acid tests.

(*d*.) Sodium hypobromite for urea in urine.

(*e*.) Ammonium bisulphide for removing oxygen from oxy-hamoglobin of blood.

The following special pieces of apparatus are desirable adjuncts:—

* (1.) A hydrometer (*i.e.*, a specific gravity apparatus for determining, specific gravity of defilmated blood, of urine, and of milk).

(2.) A cheap little direct vision spectroscope for observing the difference between oxygenated and reduced blood.

* (3.) Dugeon's sphyomograph for pulse tracings.

* (4.) A stethoscope for listening to the sounds of the heart.

(5.) Southall's cheap ureameter for determining amount of urea in urine.

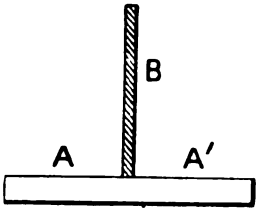
* Some of the pieces of apparatus given as essential for practical work in the Advanced Stage may be usefully employed in illustrating lectures or classes of elementary stages. These are indicated by an asterisk in the above list.

Models.—If possible, the following plaster models should be obtained: model of human brain, of human larynx, and of the parts of the human ear.

Vision.—A simple apparatus for determining the near limit of visual accommodation, to be made by taking a lath of wood about 3 feet long painted black, fixing along the middle of this a white chalked thread, and fixing on one end a small vertical card with two pin-holes. (Scheiner's experiment.)

A colour top and circular pieces of unglazed paper to go on it—red, blue, green, yellow, black, white.

A simple colour mixer may be made as follows: into the black horizontal board A, A′, 6 inches square, a vertical piece, B, of thick plate-glass, also 6 inches square, is fixed. Pieces of paper of different colours are placed on A, A′ each side of B; on looking through the glass obliquely, the colour looked at blends with that reflected from the glass surface.



SUBJECT XV.—GENERAL BIOLOGY.

For the illustration of the instruction in General Biology, it is necessary that the more important apparatus, specimens, etc., included under Subject XVI., Zoology, and Subject XVII., Botany (below), should be provided.

SUBJECT XVI.—ZOOLOGY.

A few skeletons wired to boards, besides skulls and limb-bones of animals whose entire skeletons cannot be procured, will be useful. Preparations of remarkable organs may be added as opportunity offers. Ready made dissections are not much better than pictures, and should on no account take the place of dissections made by the class.

Coloured chalks for blackboard work.

Zinc dissecting dishes—or pie dishes—filled in with blacked paraffin at the bottom to pin out structures when working under water.

Dissecting boards for larger specimens.

Scalpels, scissors, hooks, injectors, etc.

Elementary physiological apparatus should also be available.

SUBJECT XVII.—BOTANY.

Good blackboard and coloured chalks.

Diagrams for casual reference may be painted in white on black book-binders' cloth—these are more easily manipulated than cartridge paper.

Fresh material when laboratory work is in progress to be used in preference to spirit material for naked eye work. Roots and underground stems are generally *very* badly done. Every-day fruits are often very little understood.

Stock of spirit material for histological work in laboratory, labelled and kept *clean*, and with material always covered with spirit.

Lecture models are useful, but as a rule are too expensive for general adoption.

Lecture specimens in spirit—especially of things not easily procurable—or in suitable media (as for seaweeds, &c.).

Bell jars over large saucers for living culture of mosses, liverworts, fungi, &c.; also early stages of ferns, &c. Aquaria for water plants and algæ.

Apparatus for elementary plant chemistry, and for plant physiology. Test-tubes, glass and india-rubber tubing, flasks, &c., will be needed for physiological experiments. Most of the apparatus can be constructed as required by the teacher or the students.

Dissecting microscopes (these can easily be made by arranging lenses on stands, so as to be capable of being moved up and down).

Microscopes, $\frac{1}{2}$-inch and $\frac{1}{5}$-inch objectives; collection of slides, reagents, razors, watch glasses, drying racks and covers, enamel, labels, &c.

Glazed boxes of dried material—fruits, seeds, corms, bulbs, stems, buds, &c. These should be fully described in each box, and dissected out. The boxes must be air-tight.

In addition, boxes of loose dried material of all sorts which the students can handle freely.

SUBJECT XVIII.—MINING.

Typical specimens of fuels, ores, and rocks illustrating modes of occurrence.

Diagrams or lantern slides showing actual mine workings, sinking, rising, driving, breaking ground, ventilating, pumping, hauling and winding, together with the appliances in use, deep-boring tools and sections of bore-holes, underhand and overhand stoping, long-wall and pillar-and-stall methods of coal-mining, and of the other more important methods in use both in open workings and in deep mines, travelling in shafts and levels, ore dressing and coal-washing, &c.

Models of timbering, especially of the joints used, of fans and other ventilating appliances; models or diagrams illustrating faults and the rules for finding faulted veins or seams; dummy models of explosives, and a collection of safety lamps and of the simpler tools, &c.

Lantern slides showing actual underground mining operations are of much educatonal value. Photographs of such actual operations in metalliferous mines have been published by Thomas and Burrow, and of collieries by Hughes.*

SUBJECT XIX.—METALLURGY.

Specimens of the principal metals, alloys, ores, and metallurgical products, and of the refractory and other materials, fire-bricks, fluxes, and fuels used in metallurgical processes should be provided and the students should be allowed to handle them.

Diagrams or models of typical forms of furnaces, appliances, etc., mentioned in Sections I., II., III., and IV., should also be provided, as far as is possible, such as, for example: Coke ovens, gas producers, iron blast and accessory furnaces, water-jacketed blast furnaces, reverberatory furnaces for calcining, roasting, smelting, refining, puddling, open-hearth processes, etc., steel and copper converters, zinc retort furnaces, revolving furnaces,

* Lantern slides, such as those referred to, are sold by Burrow, of Camborne.

stamp battery, cyanide chlorination, amalgamation, and desilverization plants and appliances, also plans of works.

In addition to diagrams and models, lantern slides of *actual furnaces and plants, and of processes in work* might be made use of in illustrating modern metallurgical practice, the arrangements of works, etc.

SUBJECTS XX. AND XXI. *b*.—NAVIGATION AND NAUTICAL ASTRONOMY.

Large blackboard. Terrestrial globe. Celestial globe. Azimuth compass.
Beall's deviascope.
Sextant.
Chronometer.
Artificial horizon.
Patent log.
Mercurial barometer (as used by The Meteorological Office.)
Dipping needle and set of magnets.
Star maps.
Charts.
Nautical almanac.
An apparatus for showing refraction of light.
Thomson's compass.
A "log ship," for finding speed of a ship.
A box of mathematical instruments, including a large protractor.
A copy of Burdwood and Davies's Azimuth Tables.

SUBJECT XXII.—STEAM.

Apparatus for illustrating:—the properties of gases and vapours; volume, temperature, pressure; measurement of heat; Joule's equivalent; total heat of steam; latent heat; the calorific volumes of solid, liquid and gaseous fuels. Honour students may with advantage themselves design apparatus and use it for special work; for example, to find the rate at which flue gases give up heat to water through the metal of tubes. If there is a small gas engine fifteen students may help in making experiments upon it under various steady loads; finding the calorific value of the gas, say, with a Dowson gas tester; metering the gas; taking indicator diagrams, each student making an elaborate study of the diagram taken by himself as well as measuring merely the indicated power; taking temperatures and water supply of the water jacket; speed; measuring the brake horse power. Drawing up a report of the tests.

The same sort of exercise may be carried out upon a steam engine or an oil engine. When there is any chance of showing students the working of an engine of any kind, whatever is measureable ought to be measured by the students. For example, if a traction engine actually drawing a load is available for observation, the students may find the weights of the vehicles, the speed, the consumption of fuel and water, and draw up a report. If there is no opportunity for making measurements the students ought to take published results of tests from engineering papers, and arrange them in new ways, but less instruction is possible in this way. There ought to be parts of good engines which may be taken to pieces and measured, sketched and carefully drawn. Students ought to be instructed to observe locomotives at railway stations and other engines in case there is very little school apparatus. In every class there ought to be a sectional model of the simplest kind of steam engine whose valve has variable travel and lap and advance. Three models of link motions and two of radial valve gear will be found useful. If there is a workshop, models may be made by the students themselves, these may be very simple, merely to illustrate mechanism. In places where there is an electric supply, the electric power given to a small motor and the brake power given out by it ought to be measured.

While a considerable sum may be usefully expended in providing appliances for experiments related to this subject, a good teacher will find that, however little money may be available for apparatus

he has at his command some means of illustrating the subject to his students by quantitative measurements. Wall diagrams are not of much use; the usual text books are well illustrated; the teacher ought to be able to draw well upon the blackboard. When he draws a boiler with its seating and fittings, he ought to have specimens of riveted joints, of some parts of the fittings, the ends of stays, etc., for the students to examine for themselves. Should the students use a pressure gauge or indicator, or water meter, they ought to also test its accuracy.

Almost all the apparatus described as useful in teaching subject VII. will be found useful in teaching this subject also.

SUBJECT XXIII.—PHYSIOGRAPHY.

STAGE I.

SECTION I.

The apparatus in [ ] is desirable but not essential.

Balance on stand, with set of weights, 500 gm. to 0·1 gm., and pan for specific gravity determinations.

Examples of metric and English units (yd. and metre scales; 1 lb. and 1 kgm. weights; pint and litre measures).

Small cubes, about 1-inch square, of various materials (cork, wood, stone, metal, wax, &c.) to illustrate "density."

Spring balance.

Apparatus to illustrate the principle of Archimedes.

Mercury and long glass tube sealed at one end to show the principle of the barometer. [Air pump and receiver for experiments on the pressure of air.]

Large divided circle, mounted on board, with revolving arm to illustrate angular measurements.

APPARATUS FOR SIMPLE EXPERIMENTS IN MECHANICS.

Lever; pulleys; board with pulleys and weights to illustrate the parallelogram of forces; hinged board for inclined plane and friction, with roller; large model of screw and nut; simple pendulum; ordinary pendulum with bob. Skeleton cube, or tetrahedron, for showing position of centre of gravity. Indiarubber cord.

APPARATUS AND CHEMICALS FOR SIMPLE EXPERIMENTS IN PHYSICS AND CHEMISTRY.

Bunsen burner with indiarubber tubing (or large spirit lamp); iron tripod; retort stand; sand-bath; 12 glass flasks; 12 glass beakers; an assortment of glass tubing; a few yards of indiarubber tubing, large and small bore; an assortment of good corks (or indiarubber stoppers); porcelain evaporating basins; pneumatic trough or stoneware basin; glass cylinders for the collection of gases, and a few glass plates.

Spirits of wine, sulphuric acid, hydrochloric acid. Ammonia, litmus, turpentine, oil, beeswax, shellac, lime, sulphur, marble, caustic soda, copper turnings and gauze, charcoal, graphite, phosphorus, sodium, sulphate of copper; magnesium ribbon; ether. Iron wire. Copper wire. Iron wire gauze, &c. Galvanic cells and wires. Apparatus for the electrolysis of water.

Rod of shellac, vulcanite or glass and rubber to show development of electricity. [Electrical machine and insulated conductor.]

Balanced magnetic needle (compass needle). Pith balls and silk thread.

Centigrade and Fahrenheit thermometers (freezing to boiling points).

Piece of thermometer tubing with bulb to show method of filling.
Water bath. [Oil bath.]
Compound metal strip to show unequal expansion.
Air thermometer.
Pin hole camera.
Lantern with cap and slit; screen (a large sheet of cardboard suffices for small classes). [Lime-light apparatus.]
Plane mirrors of silvered glass. Apparatus to illustrate the law of reflection of light.
Glass wedge. Two 60° glass prisms. 60° bisulphide of carbon prism.
Glass cell. Coloured glasses and solutions.
Colour disc and means of spinning it.
Tin can for boiling water in. [Liebig's condenser.]

Section II.

Boyle's law tube. Model of suction pump.
Maximum and minimum thermometers; wet and dry bulb thermometer.
Barometer. Thermometer with black bulb in vacuo; two similar thermometers (centigrade).
Dew point thermometer (hygrometer) Rain gauge.
Ordnance survey maps of the district, 25-inch maps for the immediate neighbourhood, 6-inch map, 1-inch map (two copies, one with contour lines, or hill shading). Geological map of England and Wales and sectional sheets of the neighbouring districts.
Sets of typical rock specimens and minerals. Collection of minerals showing scale of hardness. Glacially striated boulder. Specimens of sea bottoms. Microscope and slides of typical rock sections. Piece of load-stone with stirrups for suspending it. Steel bar magnets with keepers.
Iron filings, knitting needles. Dip needle.
Terrestrial and celestial globes.

Stage 2.

For this stage it is desirable that the equipment should be of a similar nature to that for the Elementary Stage, but more complete. Thus an optical lantern with limelight is almost indispensable, and a spectroscope should be available. Also a larger collection of geological specimens and maps. Diagrams of ocean depths; weather charts, charts of spectra. Astronomical charts of solar system. Charts showing Isogonic and Isoclinic lines, &c.

SUBJECT XXIV.—AGRICULTURAL SCIENCE AND RURAL ECONOMY.

Thermometers, rain-gauge, geological maps of district.
Chemical apparatus sufficient for the preparation of the common gases, gas jars, beakers, platinum-foil, blowpipe.
Samples of soils, manures, dressings, food stuffs, preserved in wide-mouth stoppered bottles.
Samples of grains of various kinds, seeds of field crops, &c.
Series of ultimate elements of typical soils arranged in bottles to show composition of soils.
Diagrams or models of farm implements, plans of farm buildings, silos, storage of crops, &c., drainage and irrigation.
Drawings of live-stock of various breeds, poultry.
Herbarium of cultivated plants, weeds, grasses.
Specimens to illustrate attacks of insects and parasites, diseases of plants, fungi.
Specimens of disinfectants, deodorants, &c.
Special diagrams published for the Board of Education, South Kensington, by Messrs. Chapman and Hall.

SUBJECT XXV.—HYGIENE.

The whole of the more elementary apparatus for practical physiology, *q.v.*, including microscope with ½ in. and ⅛ in. objectives and a set of slides of the most important structures and tissues.

A set of diagrams.

Such elementary chemical and physical apparatus as shall suffice for demonstrating the properties of air and water.

Elementary apparatus for illustrating the phenomena of heat (conduction, radiation, convection)—thermometer, hygrometer, rain-gauges.

Models of ventilating appliances and elementary apparatus for demonstrating air currents. Elementary apparatus for demonstrating the properties of soaps.

Slides of specimens of parasites of all the common kinds, and spirit specimens of round and flat parasitic worms.

Specimens of materials for clothing: elementary tests of their composition, and quantitative determinations of their heat retaining properties.

Apparatus illustrating the porosity of soils. Specimen models of glazed soil pipes, and any specimens illustrating faulty drainage or faulty water supply—these obtainable from sanitary engineers when repairing old places, *e.g.*, water pipes rusted into holes, lead pipes through which nails have been driven, and so on.

Model of anti-syphonage tubes to show action.

Diagrams showing classification of food stuffs into their composite elements.

Diagrams showing standard diets: (*a*) Rest or sustenance; (*b*) Ordinary work; (*c*) Hard work.

Diagrams showing percentage composition of common foods.

Diagrams showing types of weather: (*a*) Cyclones; (*b*) Anticyclones; (*c*) V shaped depressions; (*d*) Wedges.

Barometer with model of Vernier scale to explain use of Vernier.

Specimens of the ordinary appliances used by the St. John Ambulance students.

A balance and weights, tape and yard measures. Model to illustrate absorptive power of various makes of bricks and capillarity generally.

LIST OF APPLIANCES, EXAMPLES, ETC., SUGGESTED AS SUITABLE FOR USE IN SCHOOLS OF ART AND ART CLASSES.

Primary Course.

1. Movable Blackboard.
2. Large diagrams of construction of ornamental floral, foliated and animal forms for class teaching.
3. Drawing copies in outline and silhouette.
4. Photographs of ornament.
5. Casts of simple ornament and simple sprays of natural foliage in high and low relief.
6. Photographs of simple sprays of natural foliage, flowers, or fruit.
7. Large, plane forms of various geometrical shapes, such as squares, circles, rectangles, ellipses, triangles, and polygons.
8. Complete set of models and vases as per list on page 219.
9. Common objects.
10. An elevating stand to give students exercise in drawing forms placed above the eye level.
11. Diagrams for class teaching, showing the application of geometrical construction to the setting out of schemes of ornamental patterns, construction of pattern units, tracery, etc.
12. Hinged blackboard, and blackboard T and set squares.
13. Set of simple geometrical solids with sections.
14. Model shewing ground plane, and picture plane (preferably of glass), position of spectator's eye, centre of vision and horizon line, etc.
15. Plane Mirrors of silvered glass. Apparatus to illustrate laws of reflection.
16. Text-books and books of reference.

Secondary (Advanced) Course.

1. Casts of various types of ornaments as exemplified in objects of use and in portions of architectural structure in high and low relief. The latter casts should be accompanied as far as possible by Photographs or Prints of the structure, to show the relation of the ornament to the structure.
2. Casts of fruit, flowers, foliage, and other natural forms.
3. Diagrams illustrating various historic styles.
4. Diagrams of architectural ornament.
5. Photographs of typical ornamental forms, patterns and schemes of decoration, including heraldry and lettering in use at different periods for monuments and buildings, furniture, utensils and costume, armour, &c. also of typical ornamental treatments of borders, bands, panels, medallions, friezes and pilasters, with diagrams for class lectures.
6. Diagrams of geometrical ornament.
7. Diagrams shewing resolution of natural into ornamental forms.
8. Diagrams of types of ornamental construction, such as checks, stripes, scrolls, etc.
9. Collections of ornamental casts and natural objects, such as shells, leaves, flowers, plants, etc.
10. Illustrations of the general proportions of architectural form.
11. Illustrations of classic, mediæval, and other architecture.
12. Diagrams and casts of architectural mouldings.

13. Diagrams of plans and elevations of well-known buildings, ancient and modern.
14. Diagrams of architectural construction.
15. Skeleton.
16. Anatomical figure.
17. Diagrams of bones and muscles of the human figure, male and female.
18. Diagrams illustrating the different characteristics of the child, and the adult figure, male and female.
19. Diagrams showing the influence of action upon the muscles.
20. Text-books and books of reference.
21. Diagrams of the elements of ornamental construction.
22. Diagrams showing ornamental treatment of walls, curved surfaces, vases, friezes, spandrils, etc., etc.
23. Diagrams illustrating principles of colour.
24. Coloured illustrations of decorative productions of varied styles, periods and materials.
25. Photographs of well-known compositions, ancient, mediæval and modern, examples of woodcuts, engravings, etc.
26. Apparatus for observing the effect of applied designs *in situ*, such as appliances to raise a frieze design to its proper height; vase forms to note the effect of foreshortening upon details applied to such surfaces; appliances for observation of ceiling designs, etc., etc.
27. A collection of natural objects, such as shells, butterflies, birds, plants, etc. A small conservatory would be a most useful adjunct.
28. A movable blackboard and a whiteboard (preferably of ground glass) for colour demonstrations.
29. Newton's colour disc and means of spinning it.
30. Coloured glasses and papers.
31. Diagrams or examples of decorative painting.
32. A table of technical directions (enclosed in a frame if possible) for painting in tempera, fresco, oil, and stereochrome.
33. Set of objects for still life painting, selected to show varieties of surface and colour.
34. A collection of draperies of varied textures and colours.
35. A collection of full size plaster casts from antique statues.
36. A collection of casts of details of the human figure, hands, arms, feet, heads, sections of the features, etc., etc.
37. A movable throne for the life room.
38. A movable artificial light for the life room.
39. Set of appliances and draperies to be used in different poses of the figure.
40. A set of casts of sections of the features of the human head.
41. Suitable arrangements for keeping a stock of moist clay and for storing modelling work in progress.
42. Appliances for enabling the student to prepare moulds and casts of his clay models.
43. A rotating throne for the life modelling room.
44. Sufficient rotating modelling stands for the students.
45. Set of appliances and draperies for modelling from life.
46. Boards or other apparatus for making scales of proportion.
47. A set of casts from antique figures in relief.
48. Provision for keeping living birds, fish, small animals, etc., for reference in design as well as direct study.

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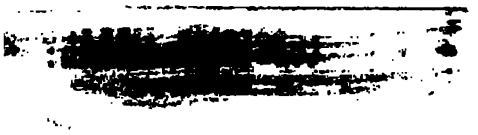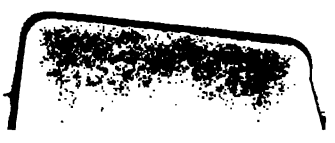
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